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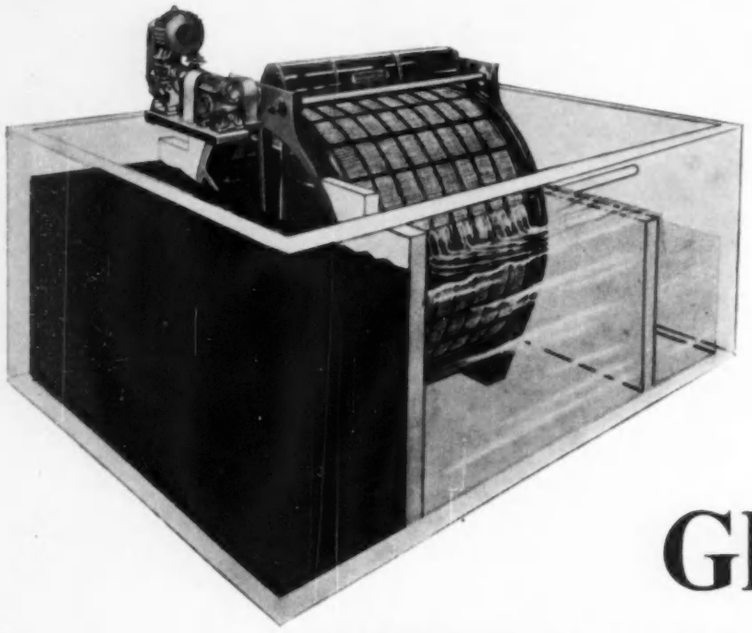

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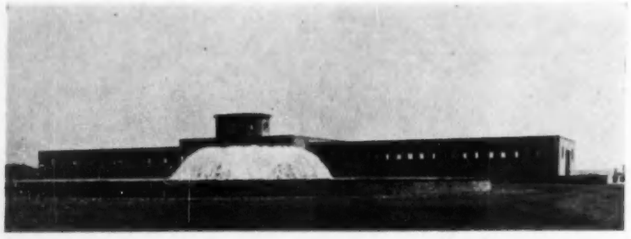

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THE ENGINEER

Established 1856

No. 5460 SEPTEMBER 16, 1960 VOL. 210

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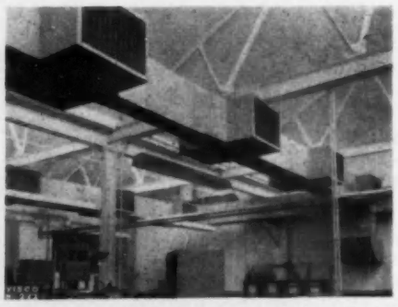

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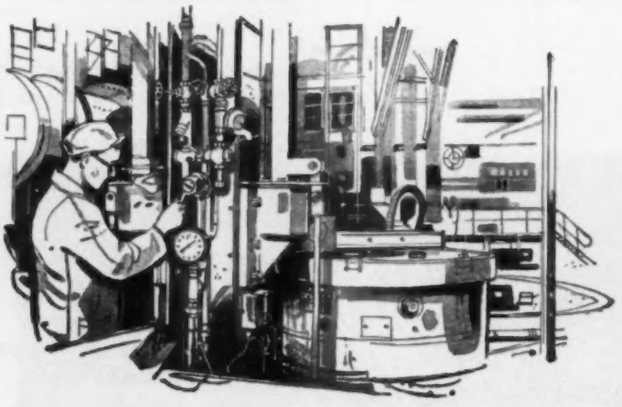

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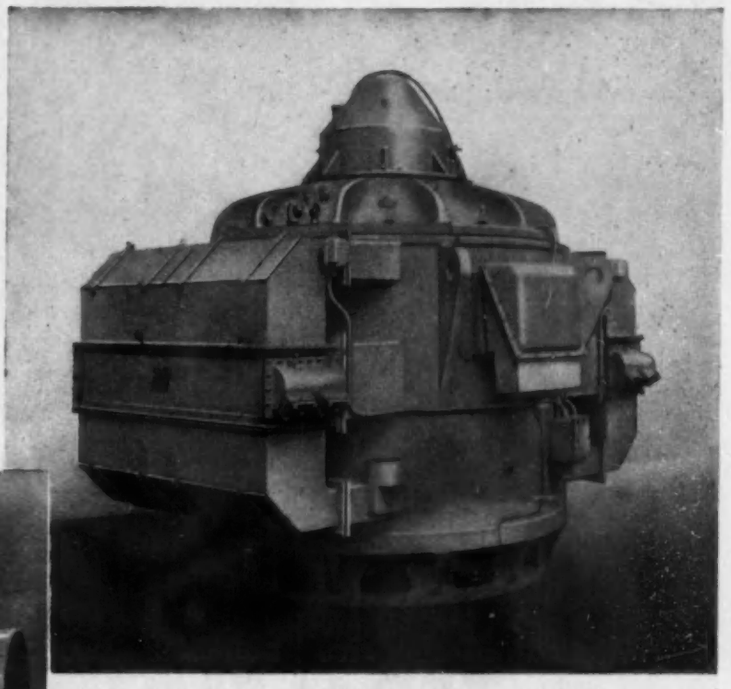
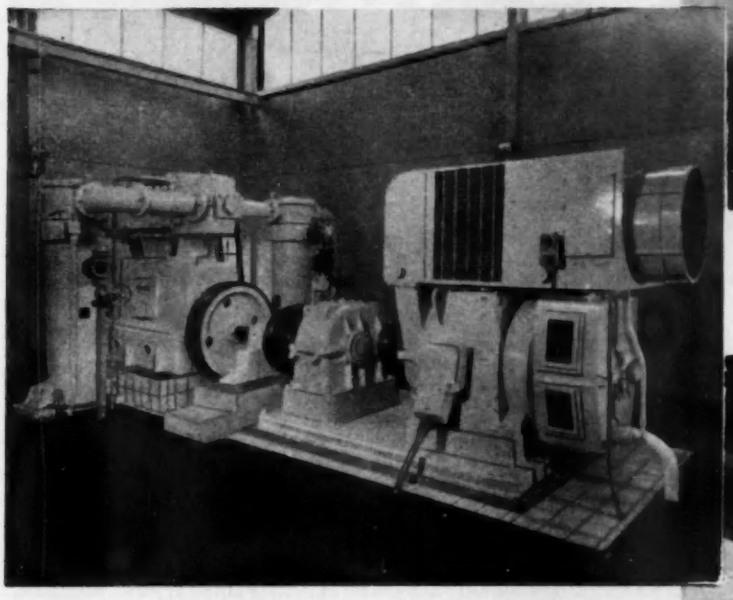


(Above) A "Trislot" motor of 1250 h.p., 595 r.p.m., 4000 volt, for pump drive. Closed air-circuit type with water cooler.



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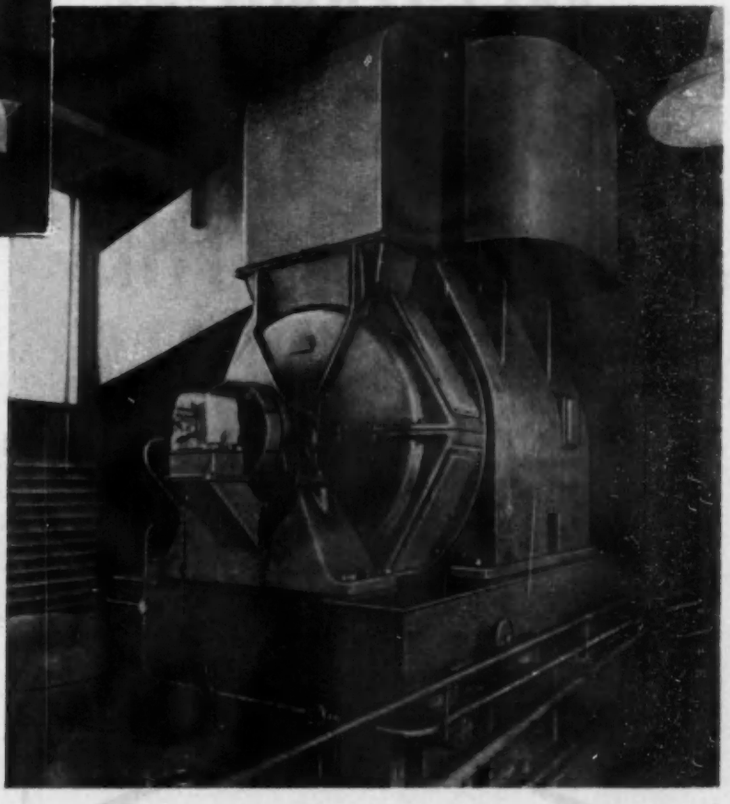

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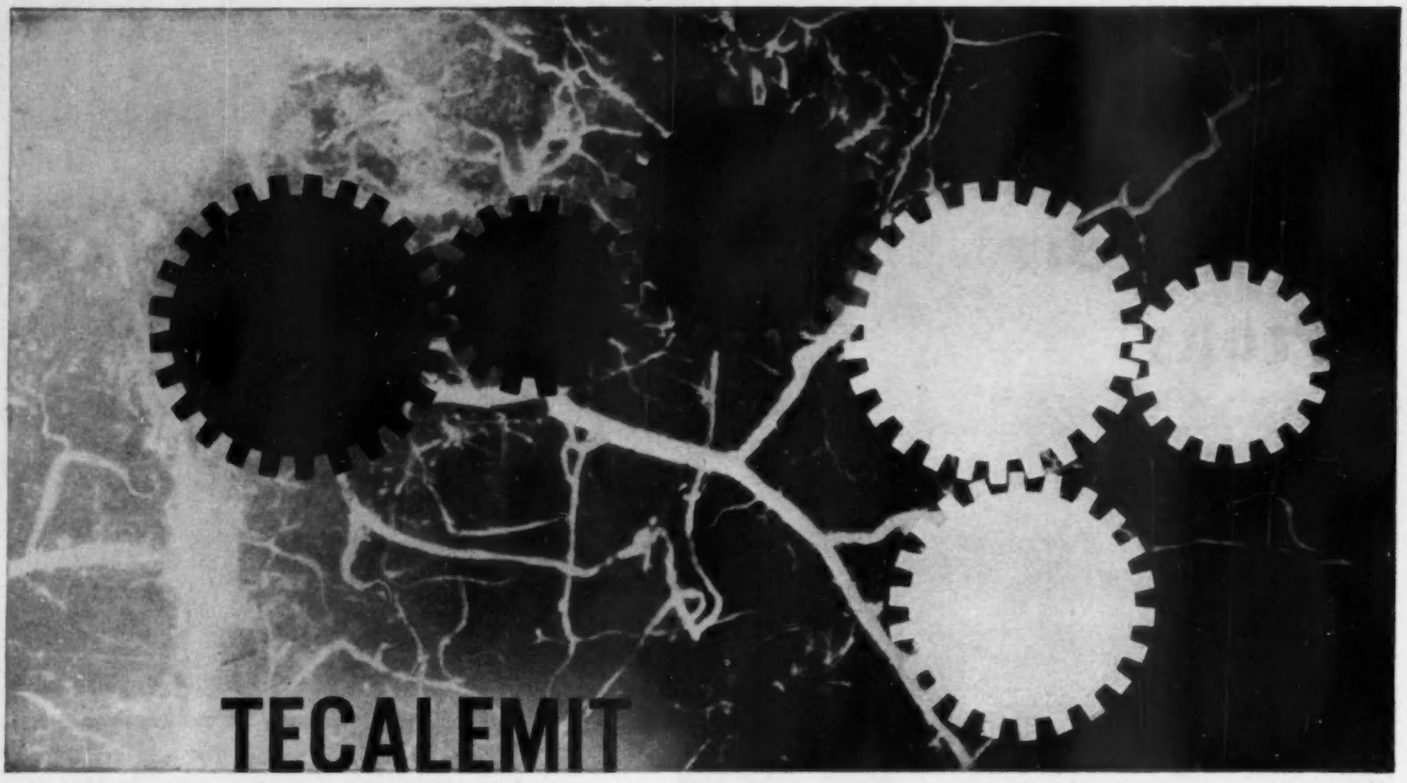

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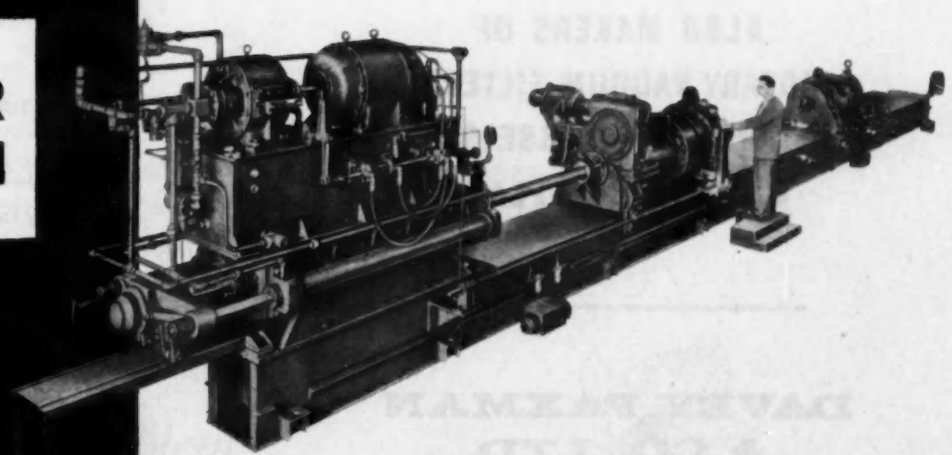

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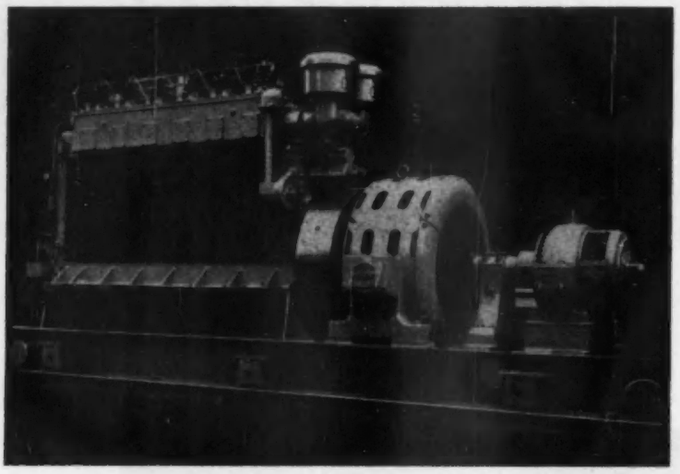

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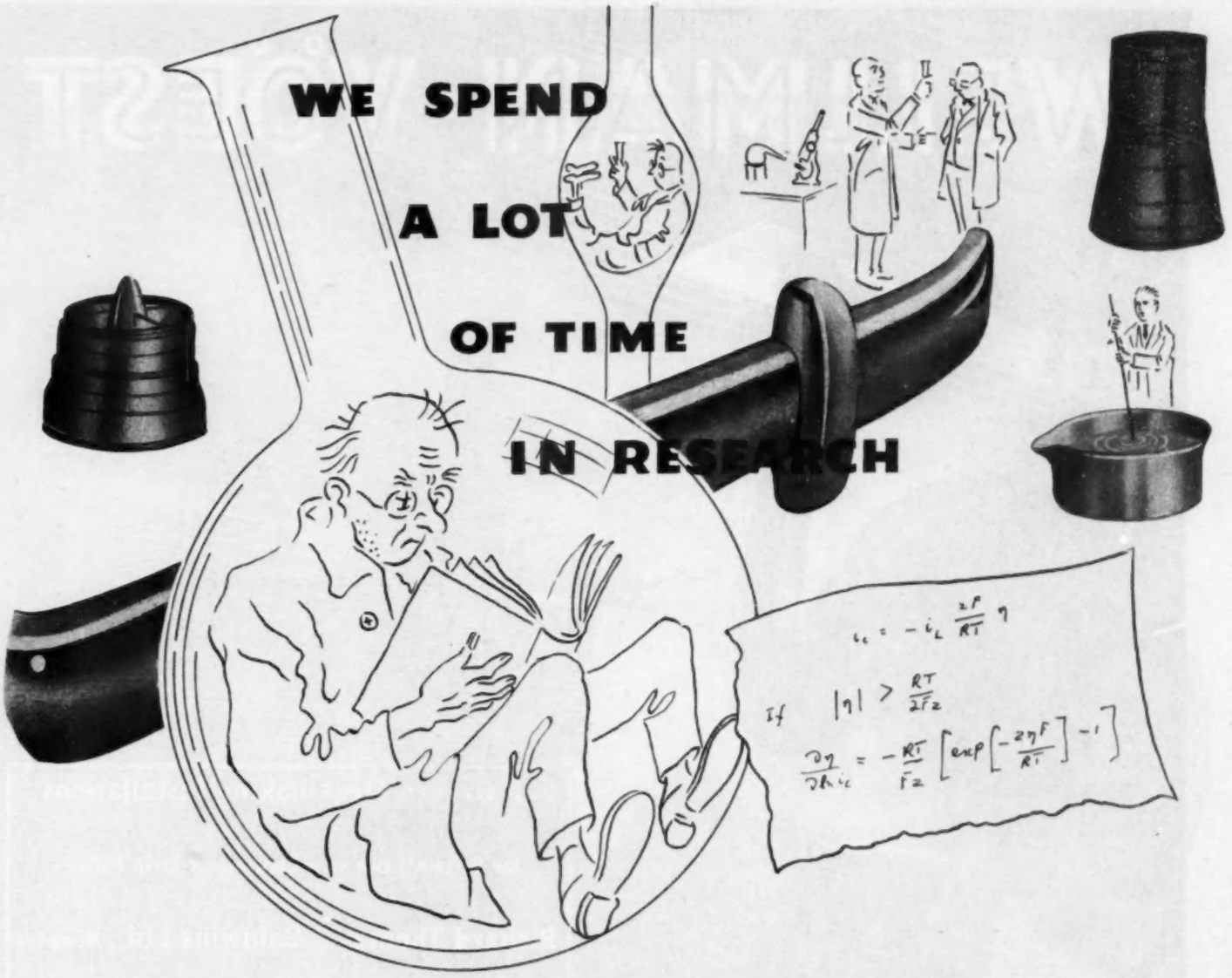

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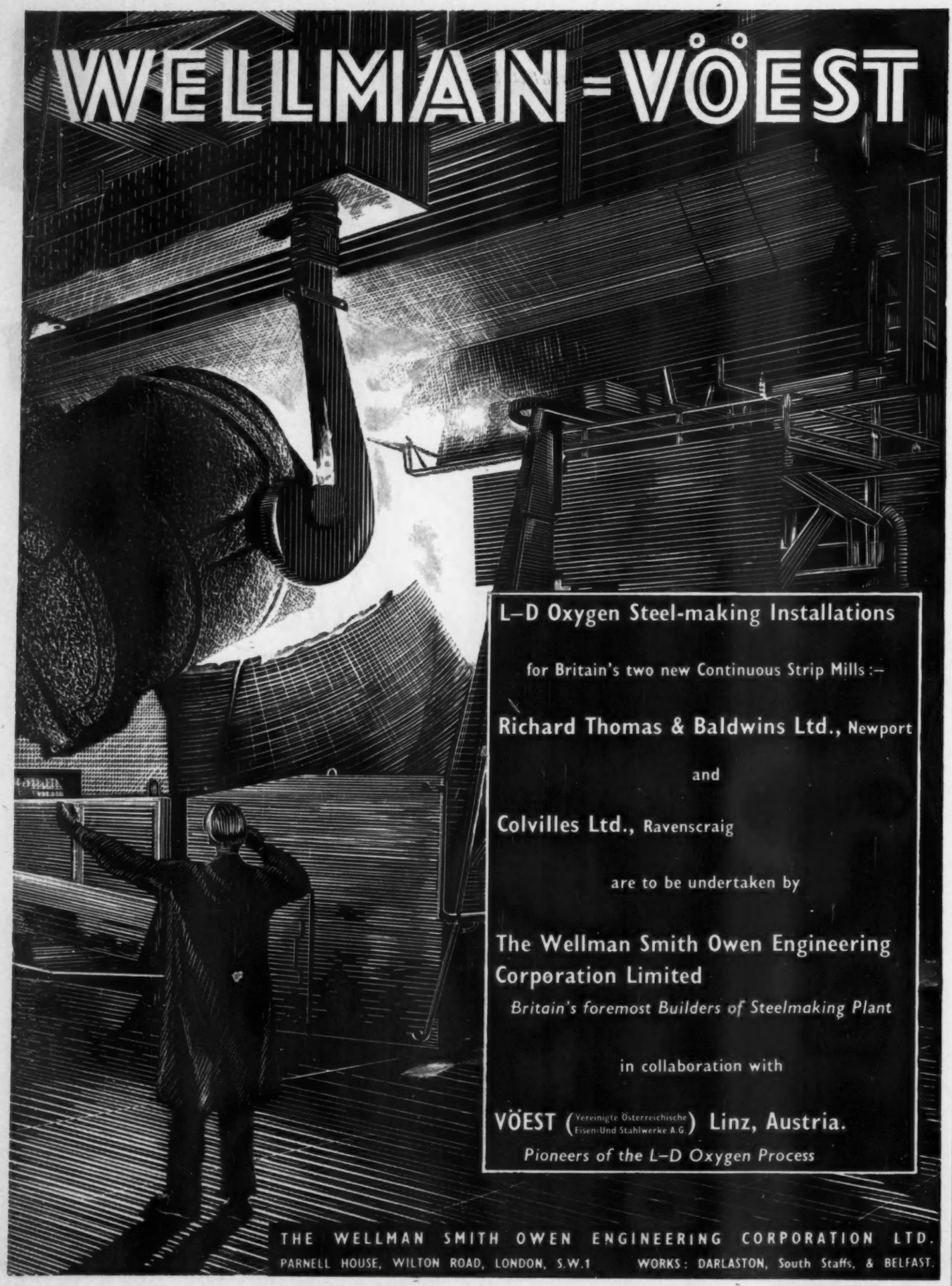

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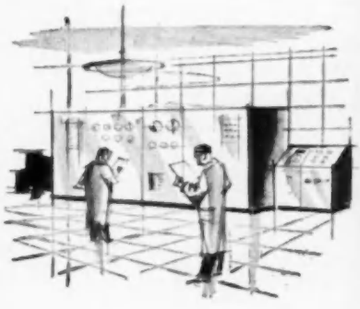

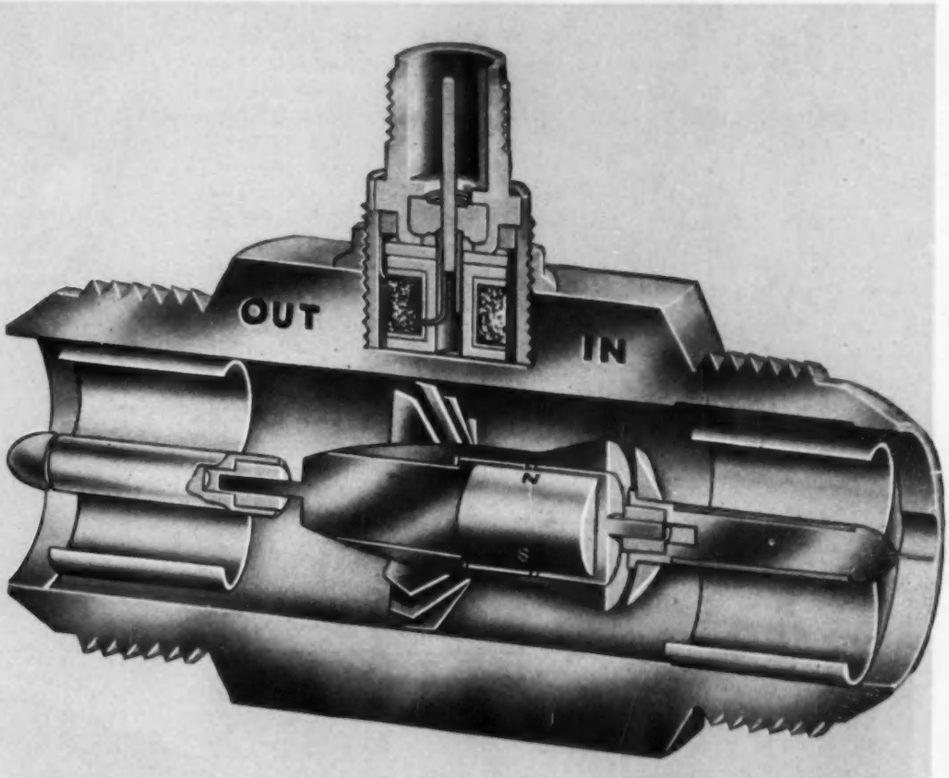

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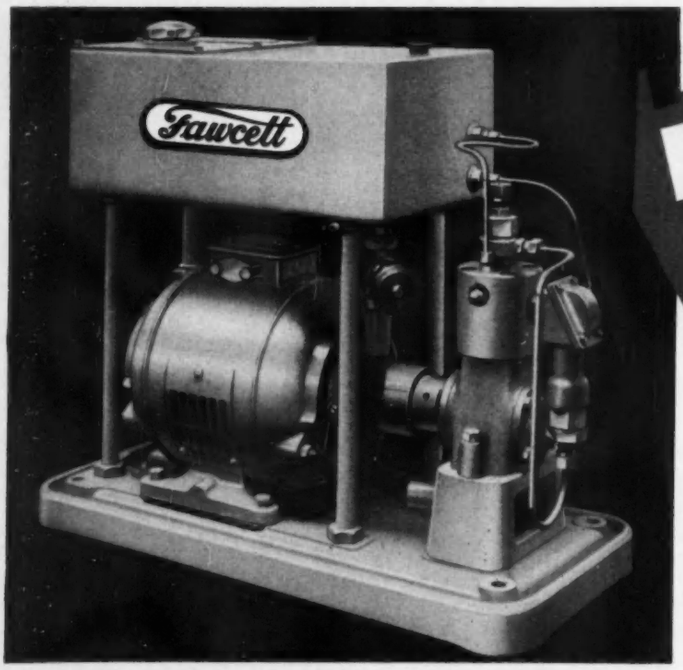

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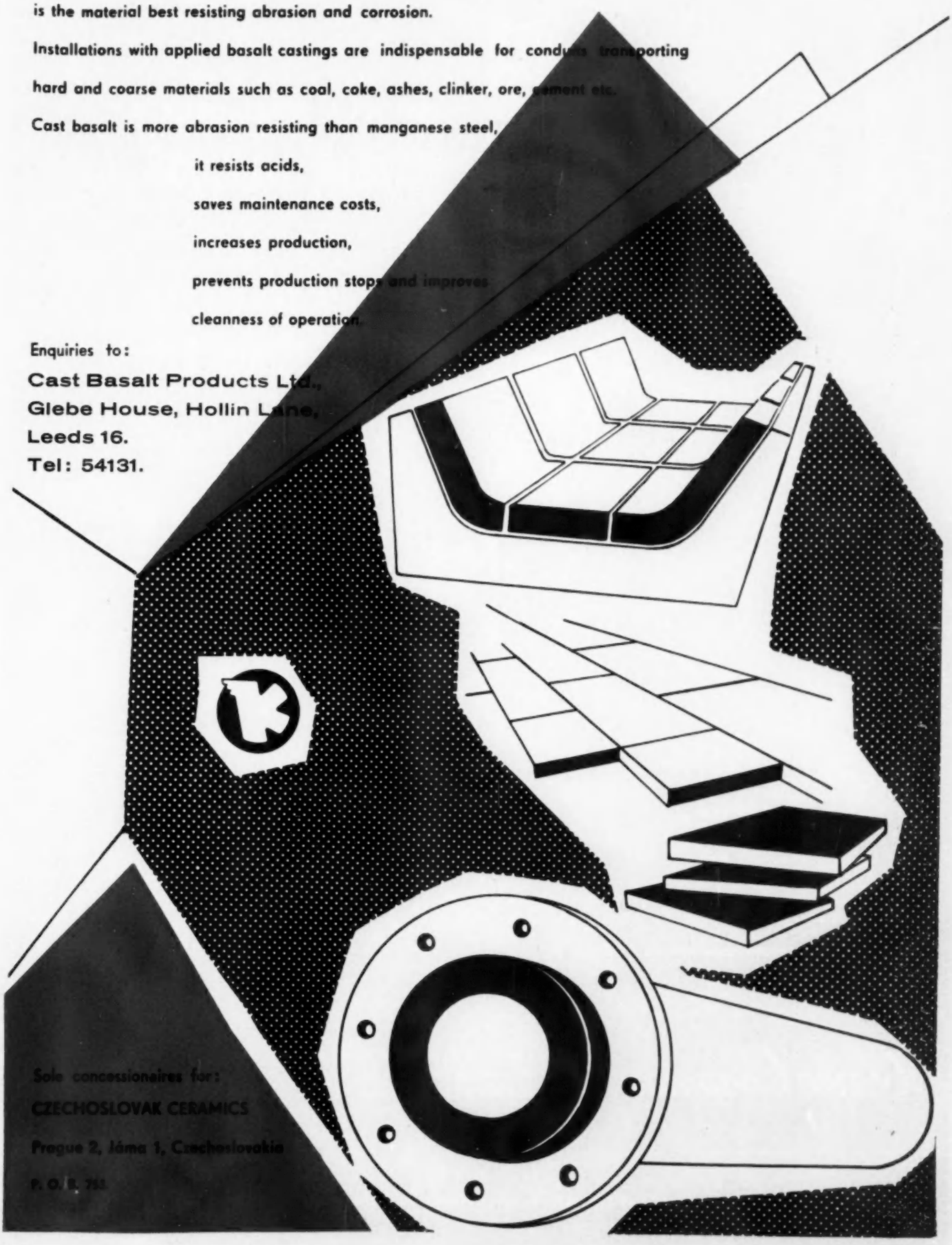

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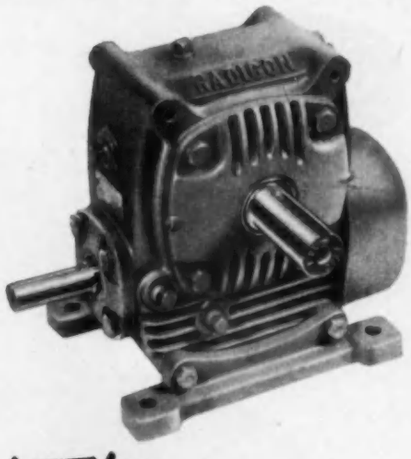

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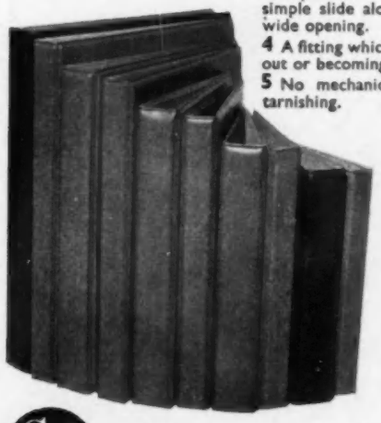

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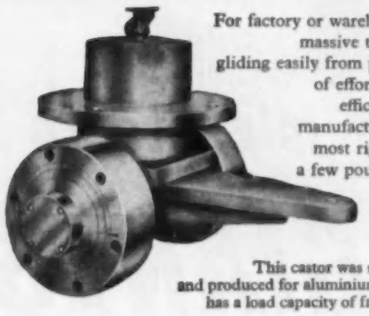

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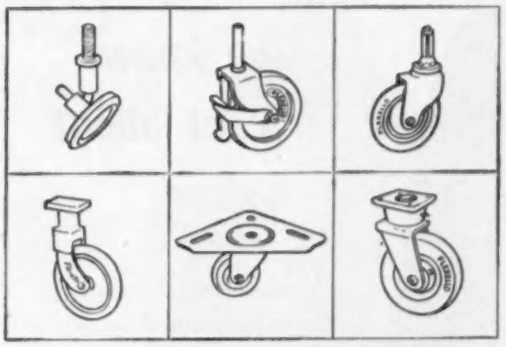

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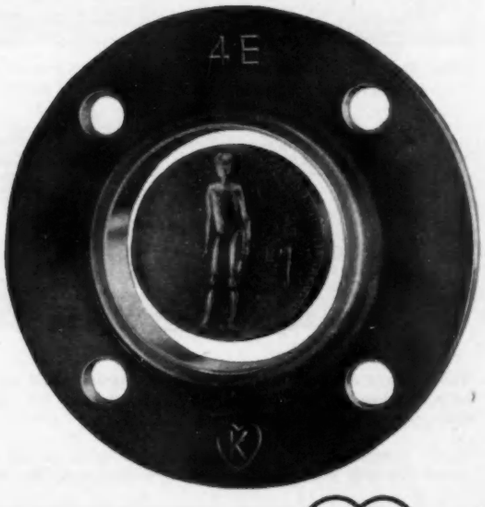

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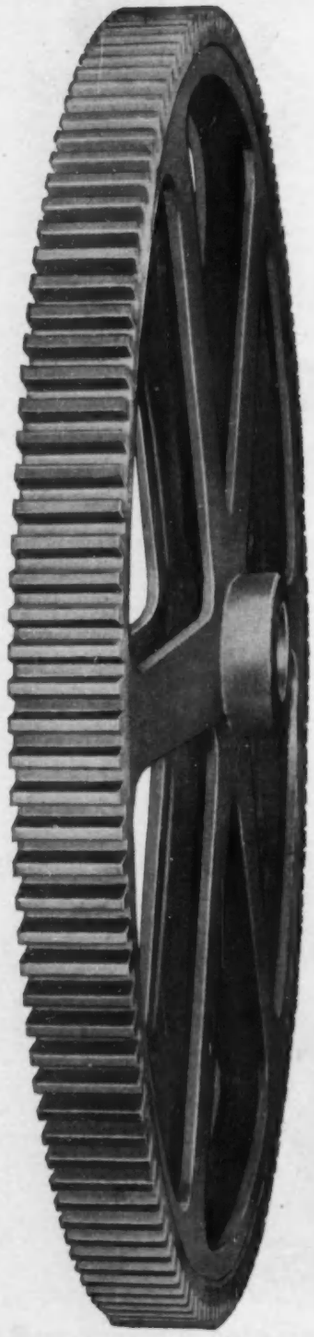

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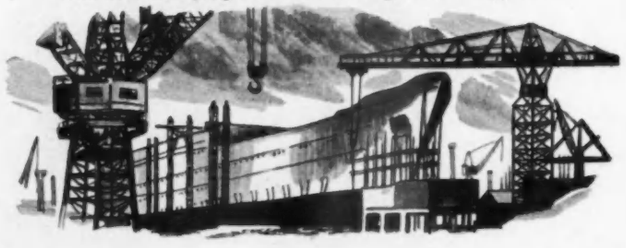

The 35 tons capacity crane illustrated is installed at the Hebburn yard of Messrs. Hawthorn Leslie (Shipbuilders) Ltd., by whose kind permission this photograph is reproduced.

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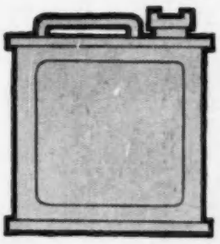

From a can of
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to a tanker of
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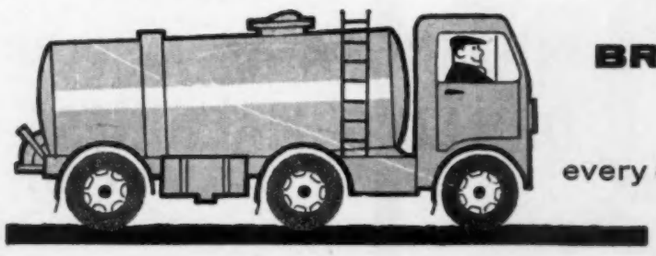

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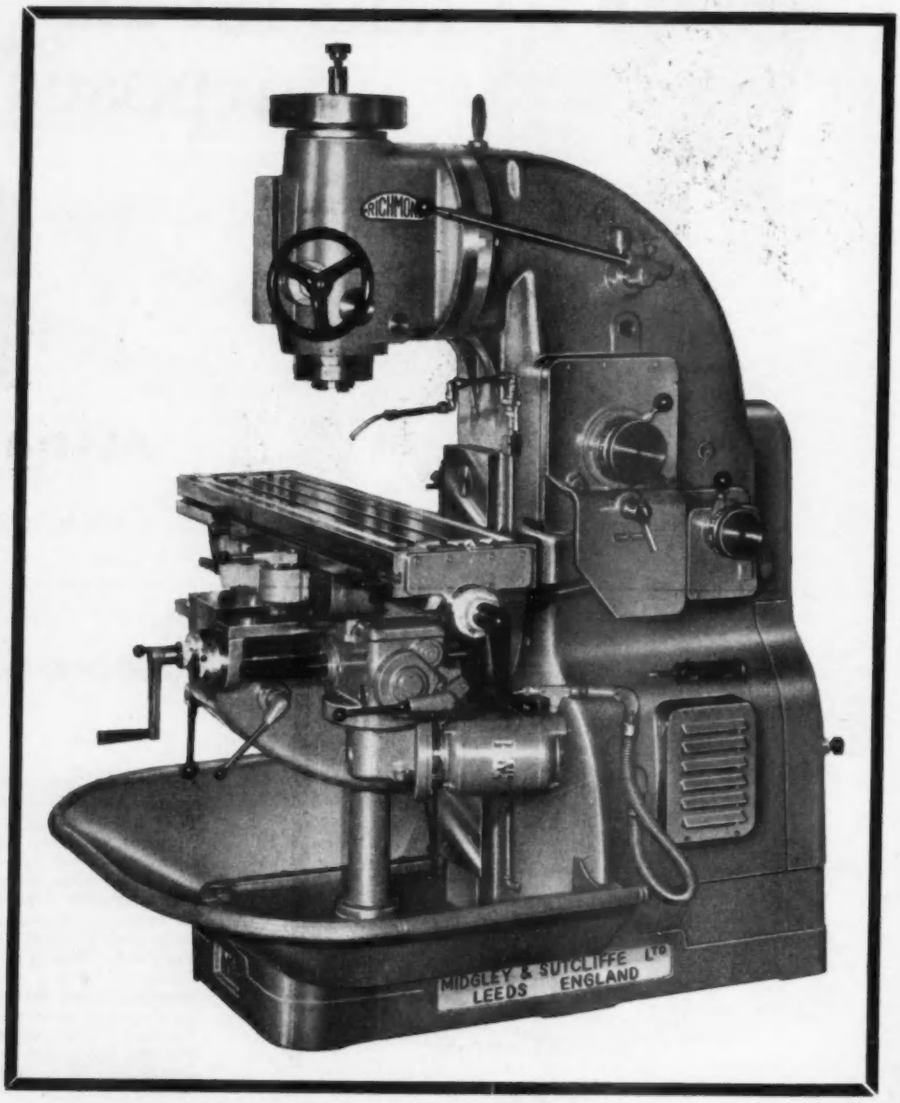

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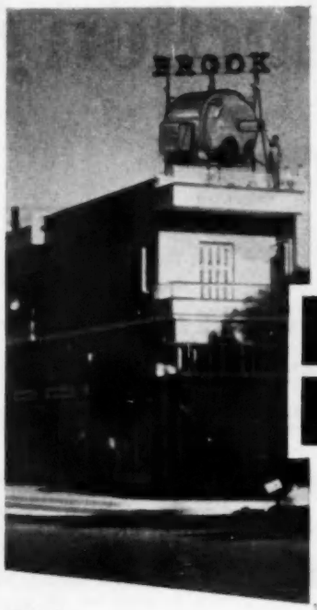

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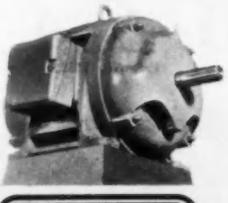

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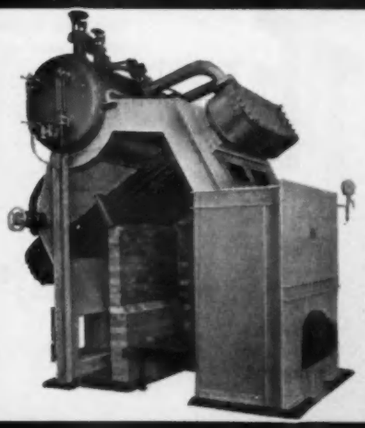

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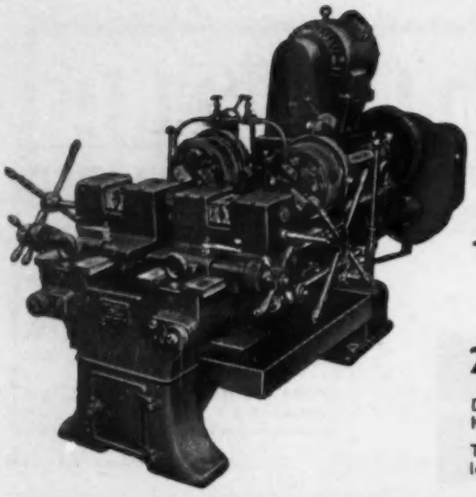

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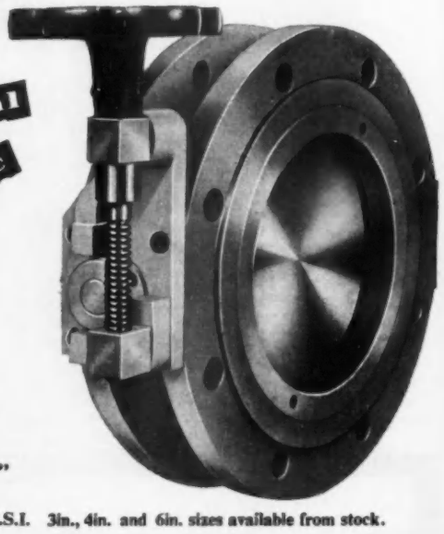

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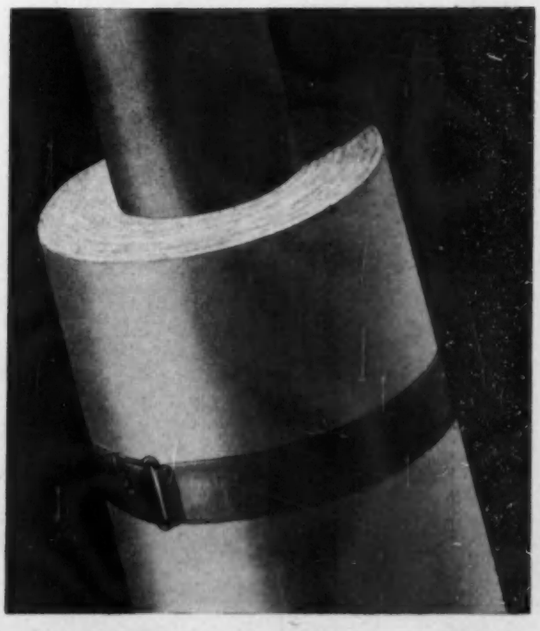

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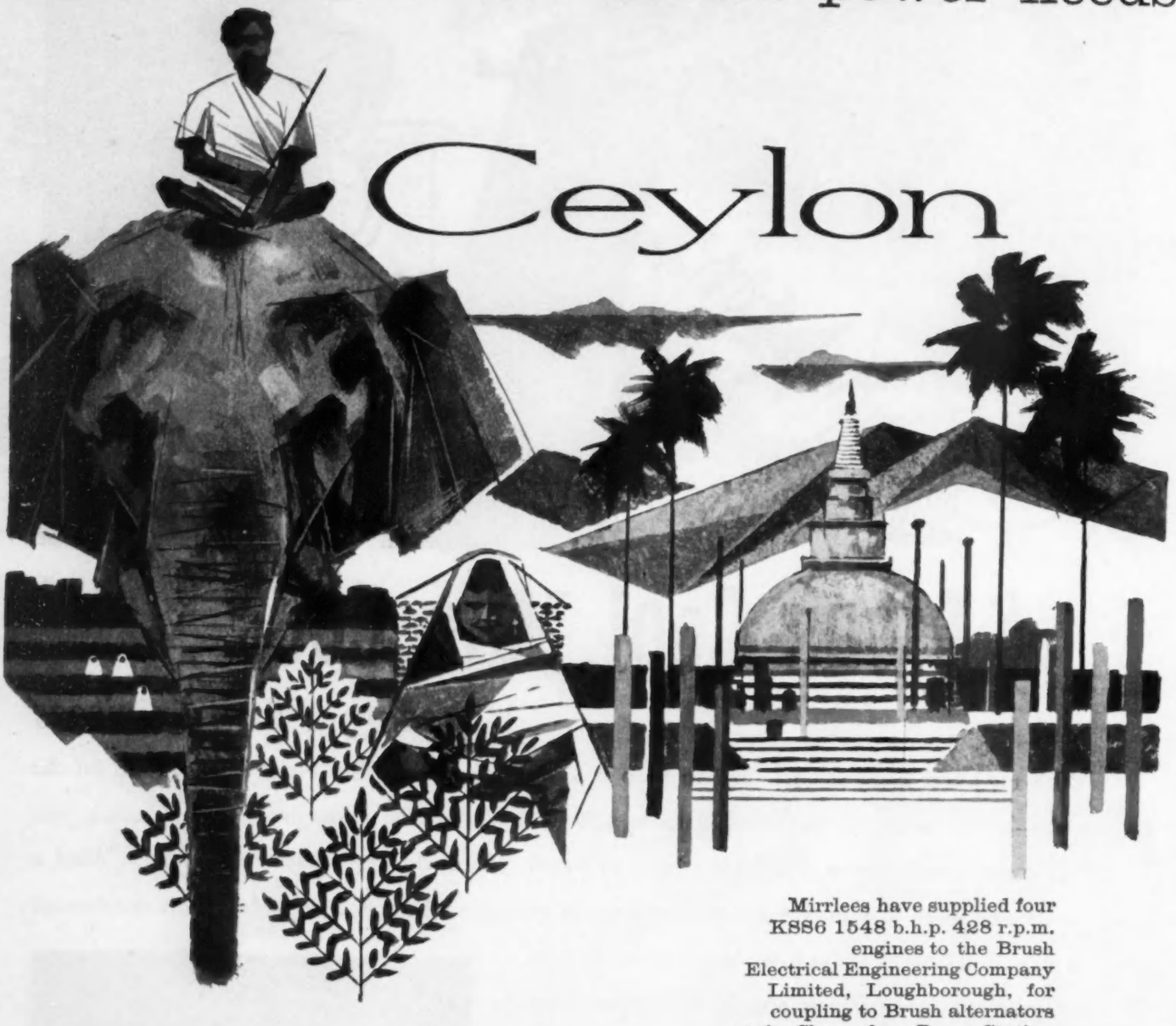

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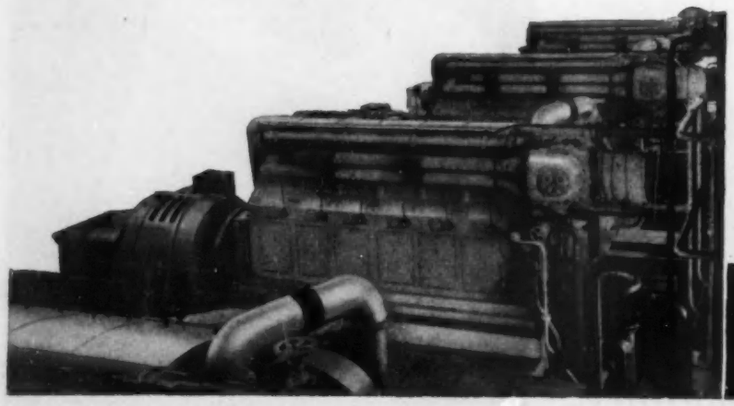

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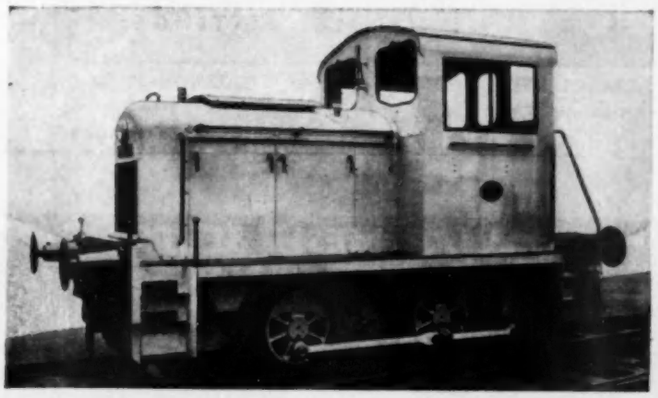
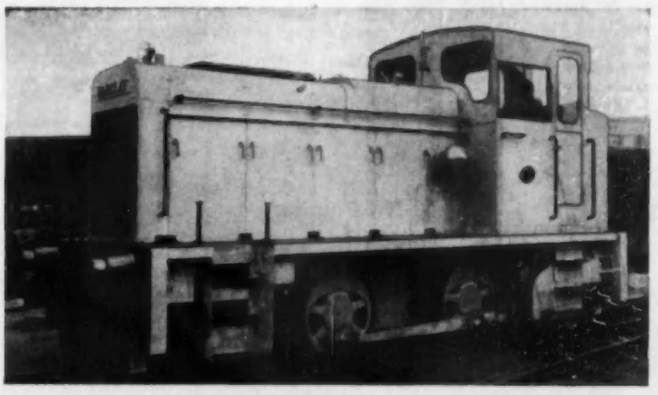


1. 85 h.p. 0-4-0 Diesel Hydraulic Locomotive, fitted with Dorman diesel engine, and a Twin Disc hydraulic torque convertor. Maximum speed about 10 m.p.h., maximum tractive effort 8,160 lbs.



2. 233 h.p. 0-4-0 Diesel Hydraulic Locomotive fitted with Rolls-Royce diesel engine and Twin Disc hydraulic torque convertor. Maximum speed is about 14 m.p.h., maximum tractive effort 21,750 lbs.

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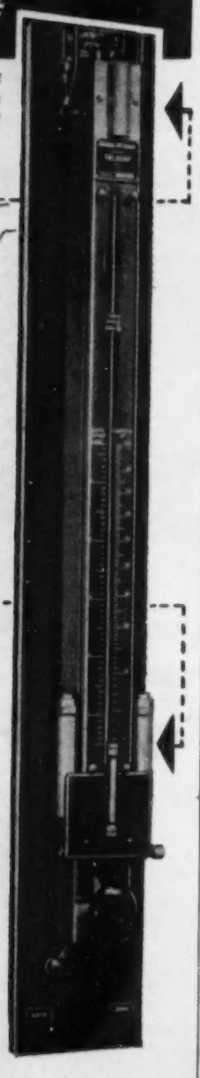

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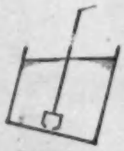

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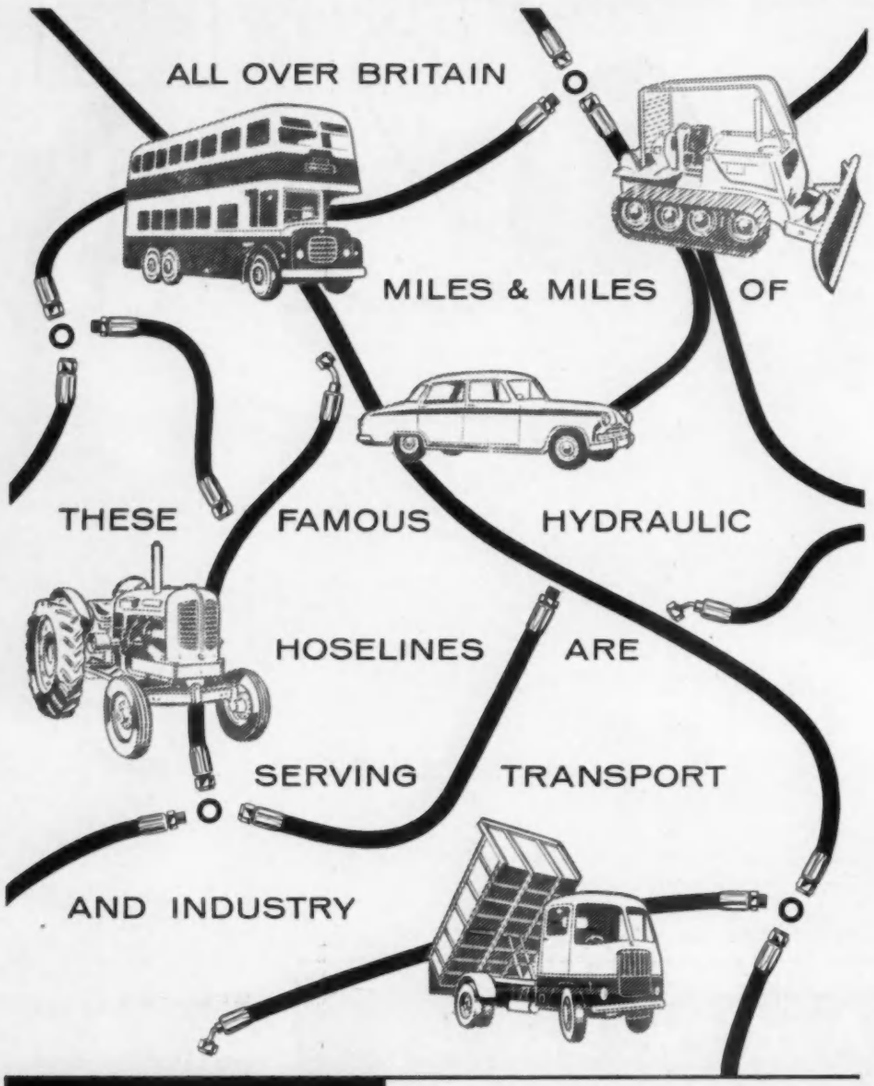

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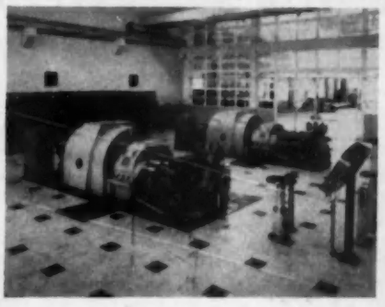
20,000 kW Radial Flow Steam Turbines installed for the Central Electricity Generating Board, York.



AXIAL FLOW STEAM TURBINES

1500 kW Back Pressure Axial Flow Steam Turbines installed for the Sugar Industry, Mauritius.

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KELVINATOR (Australia) use K.600 KOMPAKS

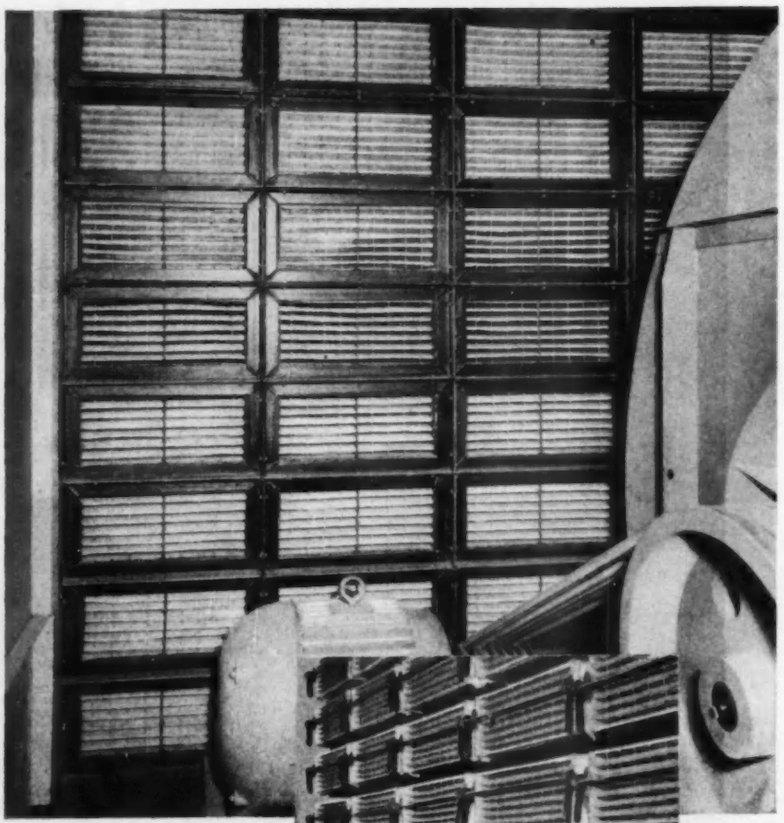
EASILY MAINTAINED FILTERS WITH GUARANTEED HIGH EFFICIENCY

Further proof of the popularity and high efficiency of the Vokes K.600 'Kompak' air filter comes from Kelvinator (Australia) who manufacture domestic and industrial refrigerators. Their problem was to keep dust and dirt out of air supplied to the paint shop. The standard of paint finish on the cabinets is exacting and the high gloss paint used accentuates any dirt defects.

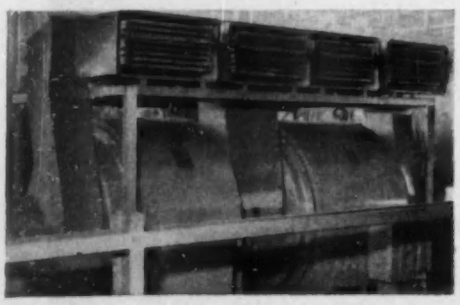
It was decided therefore to install a bank of seventy K.600 'Kompaks' as secondary filters in each of the first and second coat air systems. 'Kompaks' were chosen because of easy maintenance, the facility with which they can be built into banks without any additional framework, and their outstanding performance—a guaranteed efficiency of 99.9% against particles down to five microns in size, and a unit capacity of 600 cu. ft. per minute with initial resistance of 0.15 w.g. at normal rating.

The installation of these filters has proved completely satisfactory; fibrous particles, slagwool and lint are effectively removed from air supplied to the paint shop and it has been found that painting operations can continue even when individual primary filter cells fail owing to short circuits, etc.

The 'Kompaks' require servicing only at long intervals; when replacement of the inexpensive filter medium *does* become necessary it can easily be carried out by unskilled labour.



The illustrations on the right show (above) the clean side and (below) the dirty side of one of the banks of seventy 'Kompaks' used by Kelvinator.



Another application for this widely used low priced air filter. Four Vokes K.600 'Kompaks' giving trouble-free service on Alternators at British Tube Mills in Adelaide, South Australia.

Please write for comprehensive literature on the 'Kompak' and Vokes' other air filters.

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A|A

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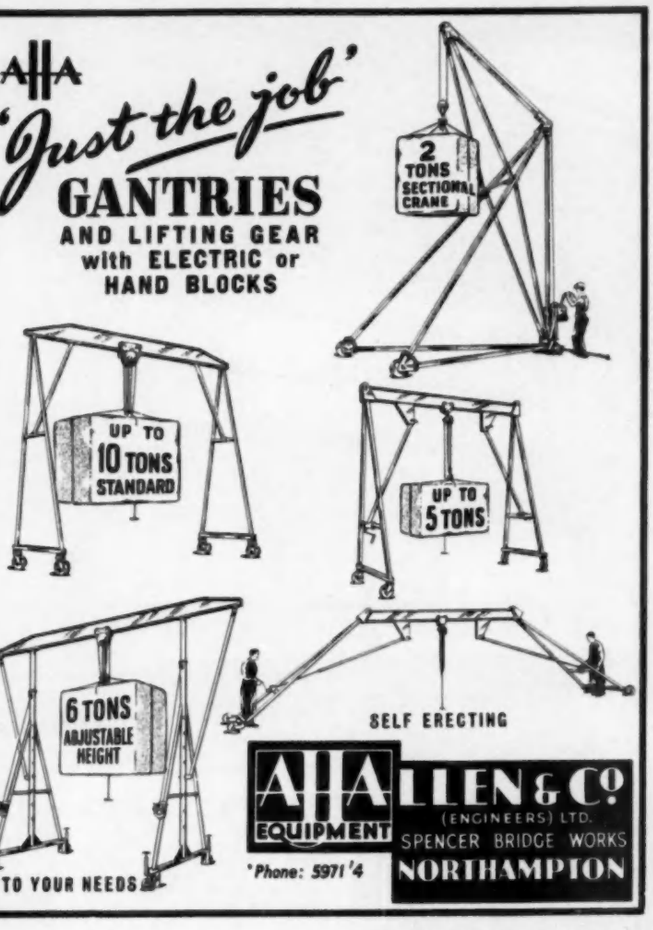

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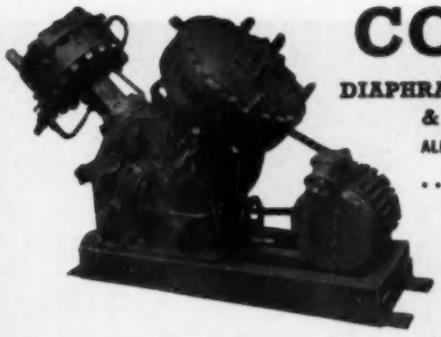

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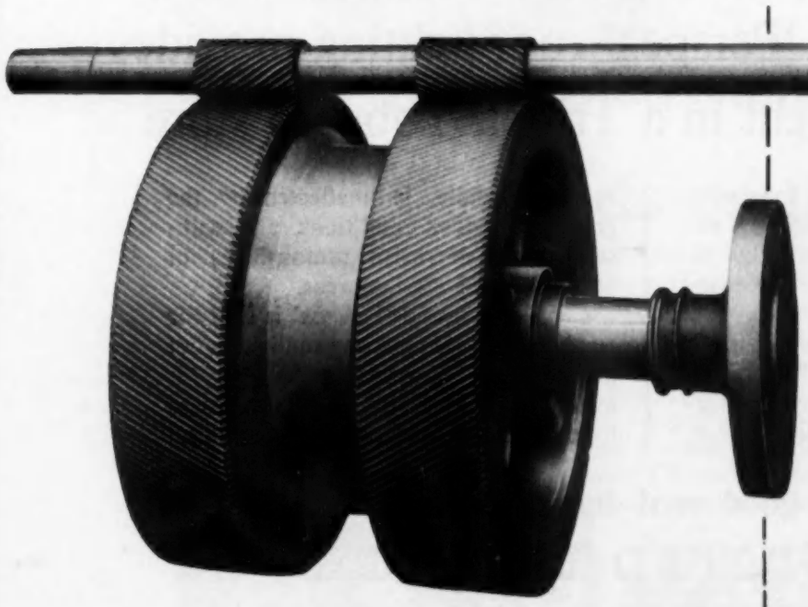

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Opal Corrugated 'Perspex' roof lighting provides ideal working light in a Tripoli Tobacco store

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'Perspex' is the registered trade mark for the acrylic sheet manufactured by I.C.I.

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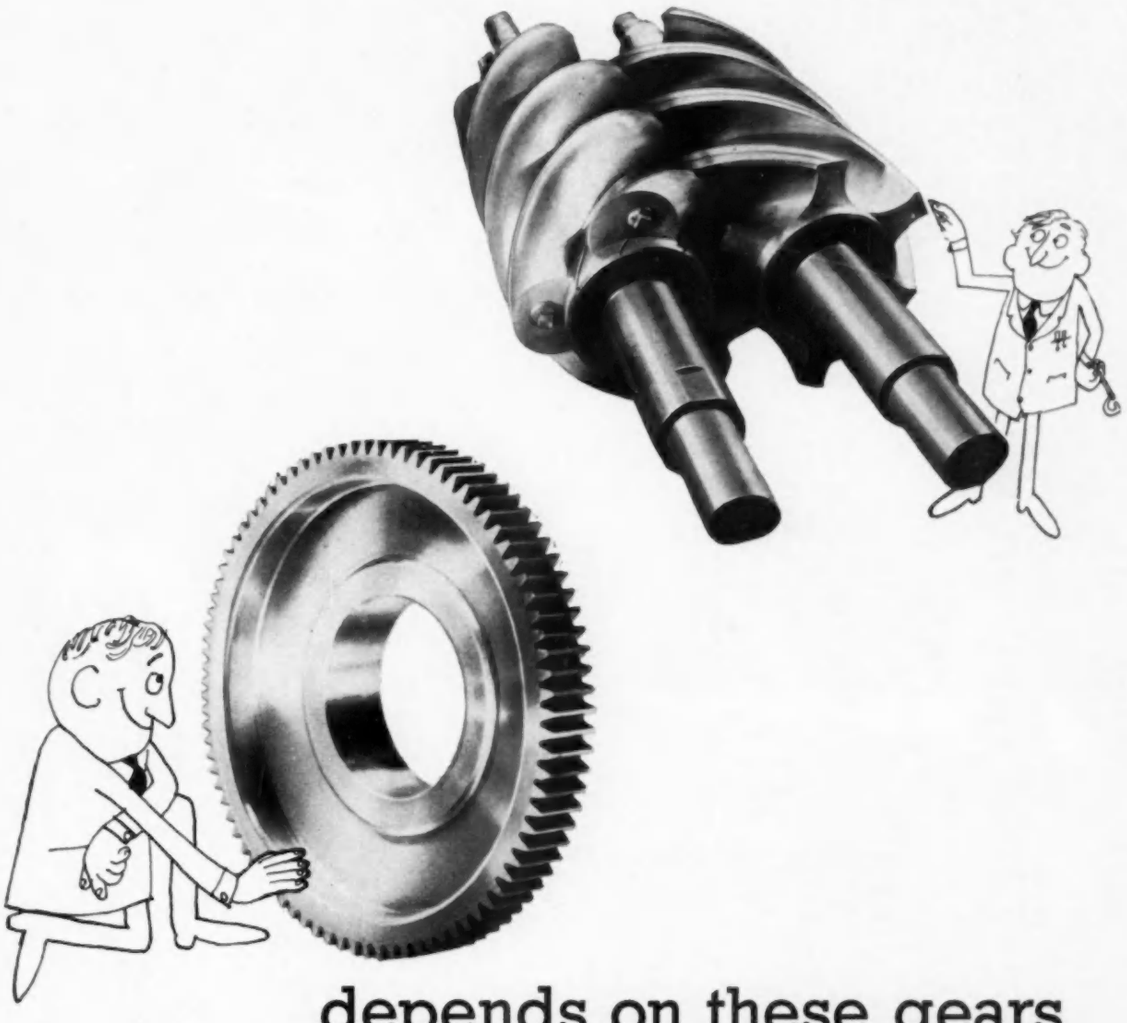
A rotor revolution



depends on these gears

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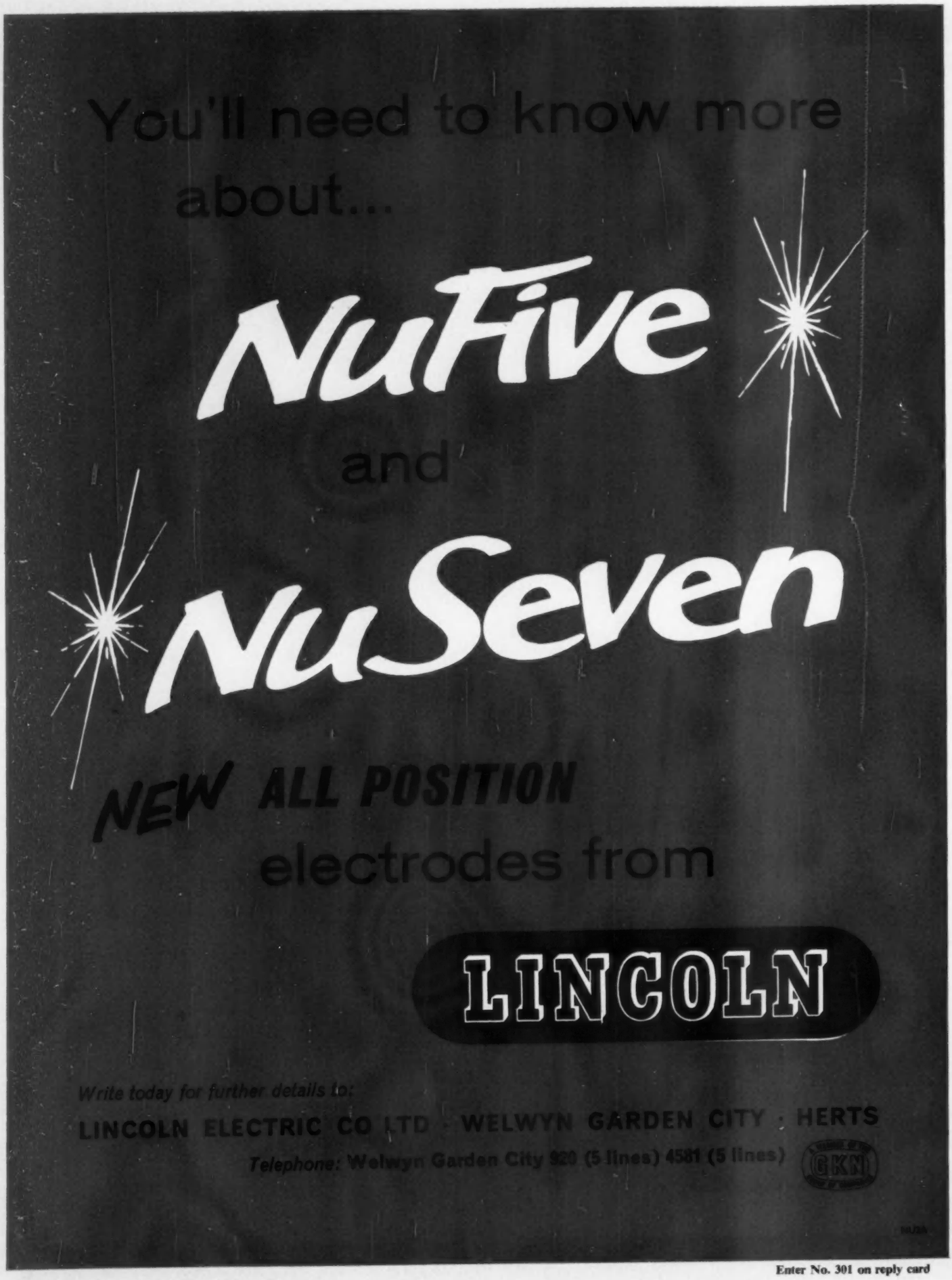

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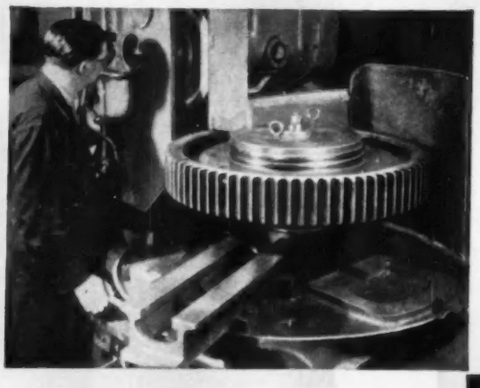

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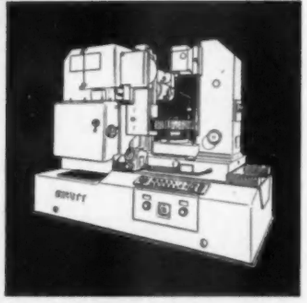

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What Mr Jones* said about the Smiths . . .

* **Mr. Alwyne Humphreys Jones, F.R.I.C.S.,** is Chief Engineer to the Gwynedd River Board, Wales. Mr. Jones made a flying visit to our headquarters, at Rodley, with transporter vehicle and crew, to pick up a new SMITH 12 DRAGLINE — the NINTH such machine supplied to the Gwynedd River Board.

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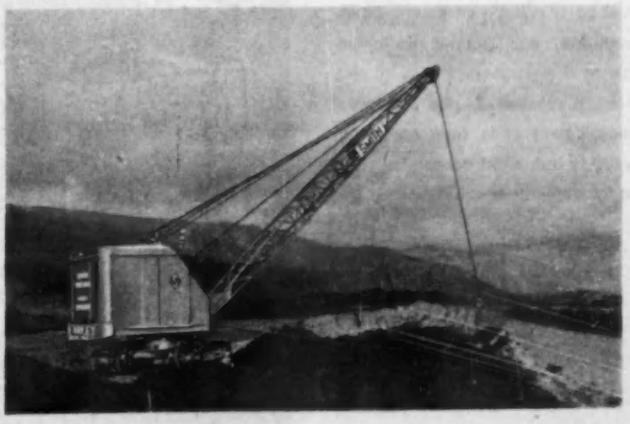

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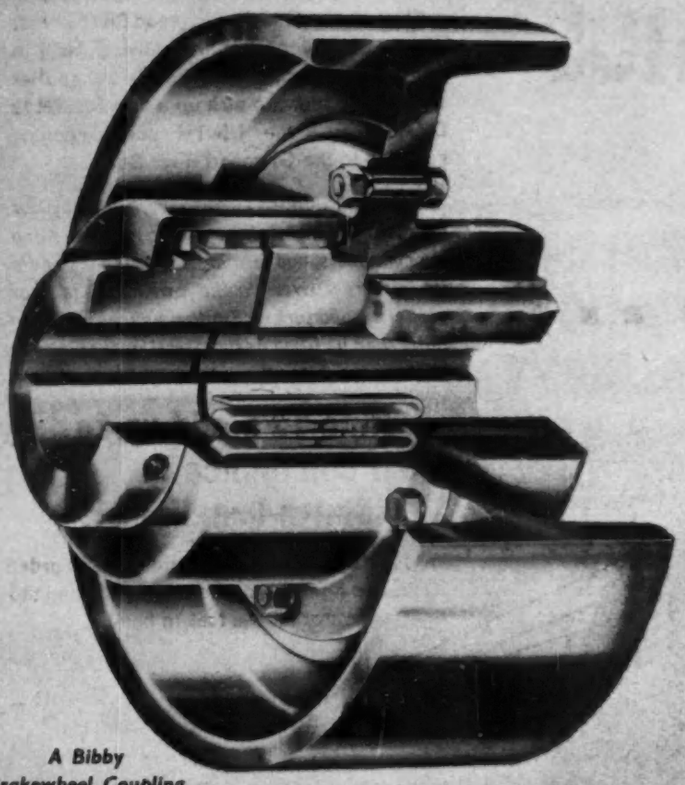

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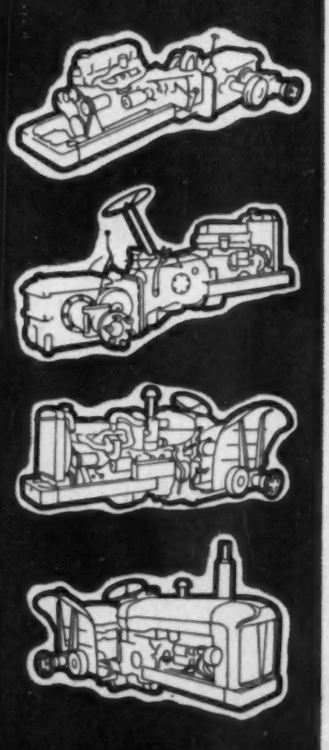

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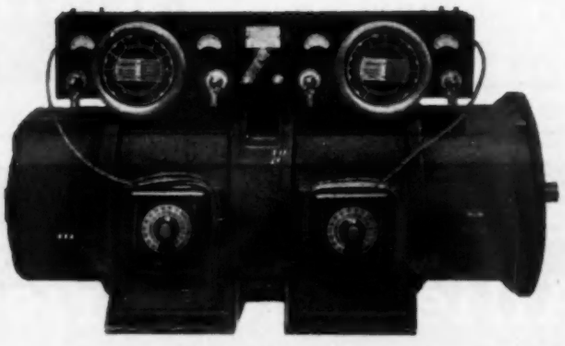
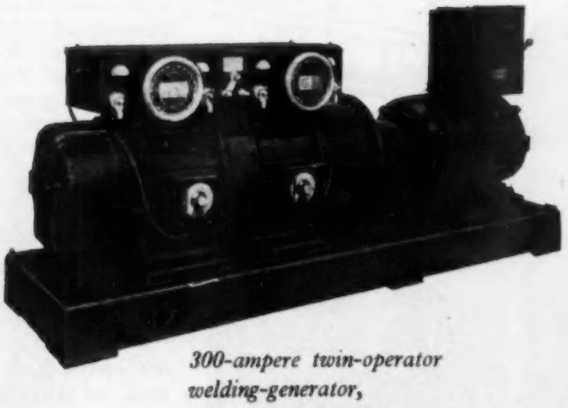


300-ampere twin-operator welding-generator with dual-control



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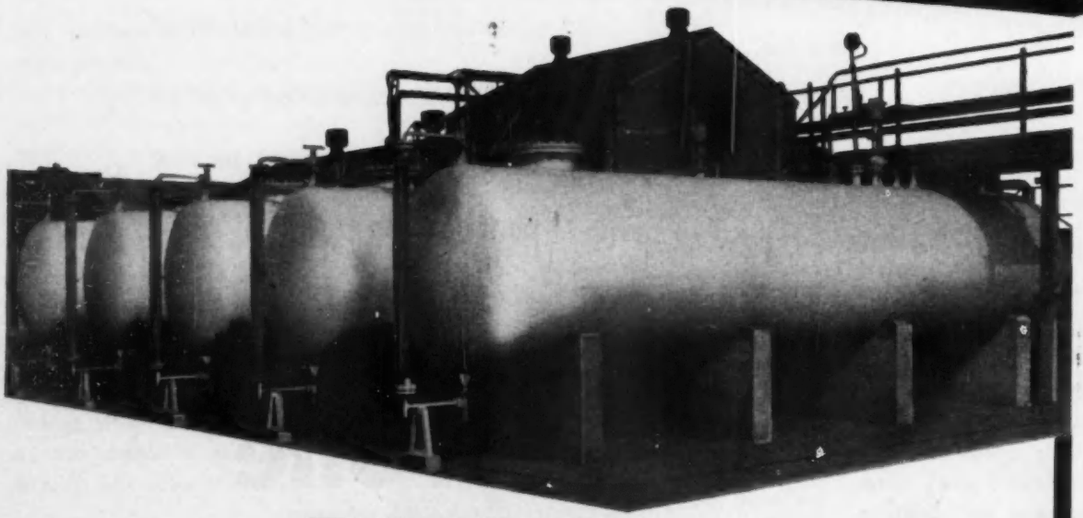

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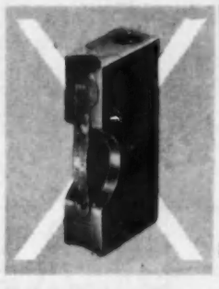

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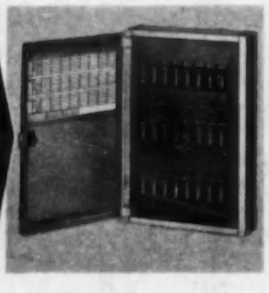

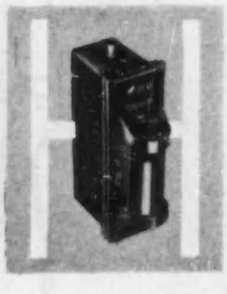

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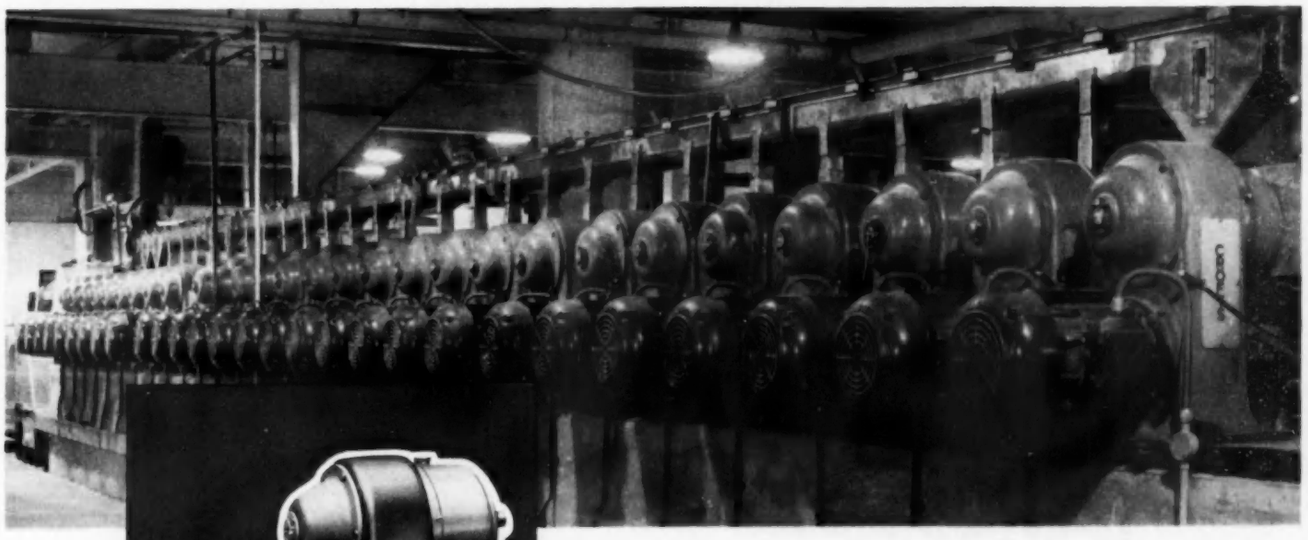

Yes, Crofts Variable Speed Motor Gears take the biscuit — that's what they'll tell you at the cereal factory where we photographed this battery of twenty-nine in action.

Combining a flange mounted electric motor, variable speed drive and appropriate reduction gear, Crofts V.S.M.Gs are ideal for installation wherever a single compact unit is required because of limited space.

The Vertical type, for powers up to 20 hp, is shown here, but a whole range of sizes is available and one's bound to suit you. Send for publication 560TE giving all the information you'll require.

Crofts

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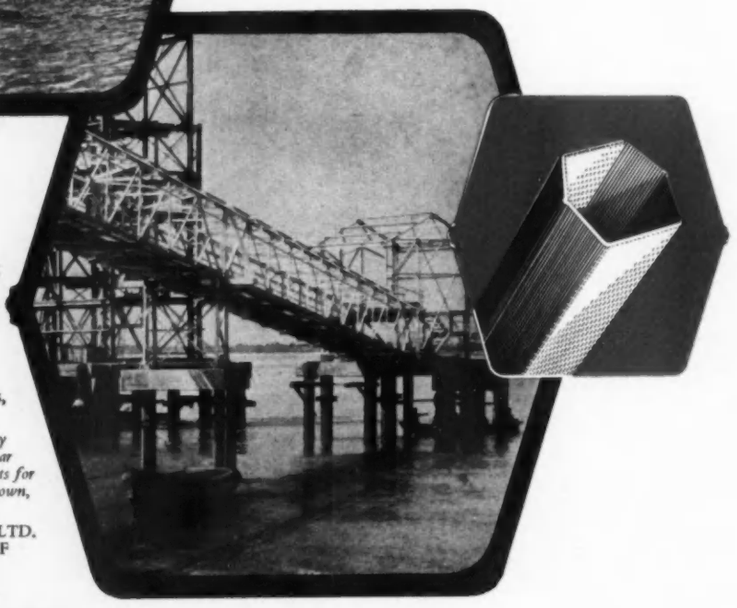
FOR SECURE FOUNDATIONS IN DEEP WATER AND TIDEWAYS "RENDHEX" FOUNDATION COLUMNS



South Durham "Rendhex" Foundation Columns combine lightness in weight with great strength and maximum load-bearing capacity. They are in world-wide demand for the construction of deep-water foundations for off-shore anchorages and all types of work where piling construction is required to carry heavy vertical loads,

Illustrations show "Rendhex" Columns forming (above) a "strongpoint" in a recently constructed jetty to berth 10,000 ton bulk sugar freighters and (below) acting as piling supports for a bulk sugar off-loading conveyor at Georgetown, British Guiana, for

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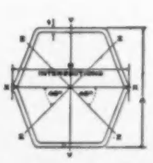

TABLE OF PROPERTIES

"Rendhex" Column No.	Size (Ins.)			Weight of Rolled Section lbs. per Lin. ft.	Weight of complete Col. (incl. Weld) lbs. per Lin. ft.	Area of complete Col. (excl. weld) Sq. ins.	Moment of Inertia (Ins.⁴)			Radii of Gyration (Ins.)			Section Moduli (Ins.³)		
	A	B	t				About XX	About YY	About ZZ	About XX	About YY	About ZZ	About XX	About YY	About ZZ
No. 3	13	12½	½	36·15	72.50	21·26	469·3	381·3	425·3	4·69	4·23	4·47	72.20	58·70	57·30
No. 4	16	16½	½	58·30	117·75	34·30	1214	1038	1126	5·95	5·50	5·73	151·75	125·82	116·15
No. 6	20	20	0·7	80·70	162·80	47·47	2657·7	2203·5	2430·6	7·49	6·81	7·16	265·80	218·60	207·20

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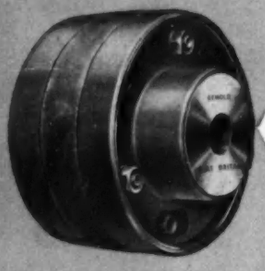

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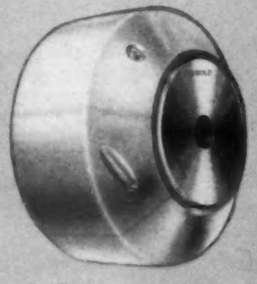

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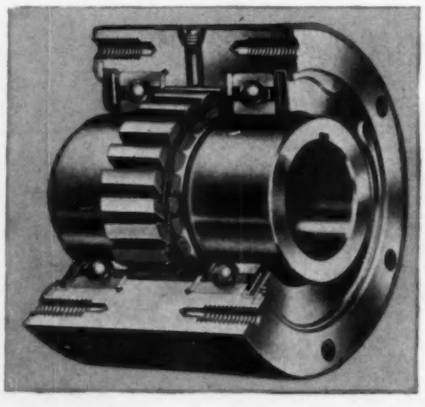

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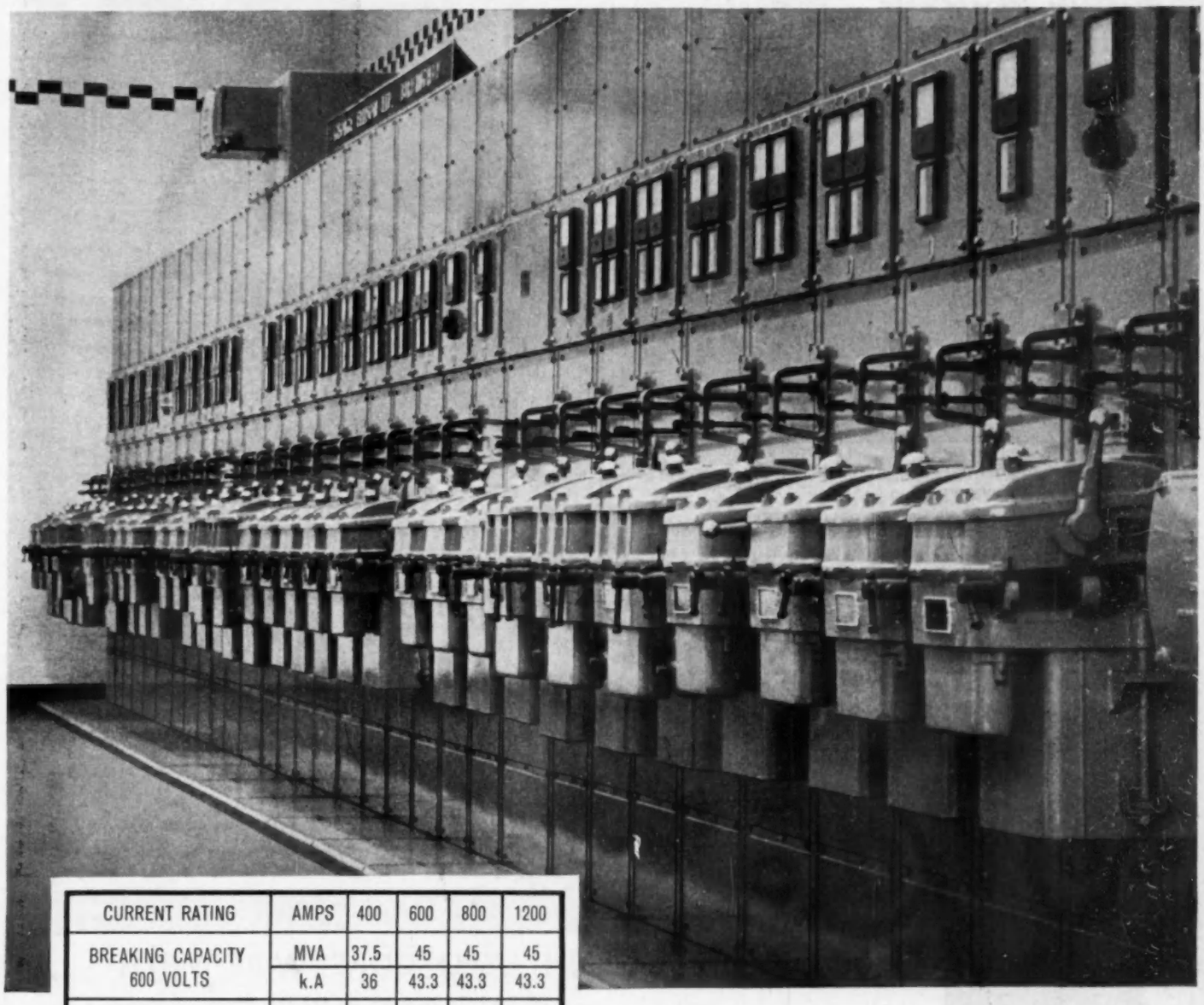

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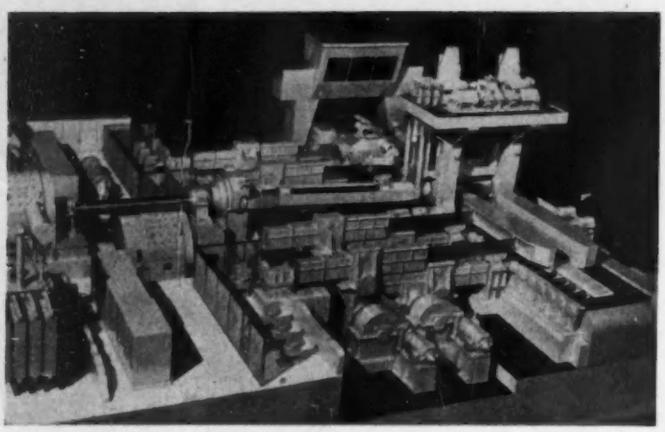

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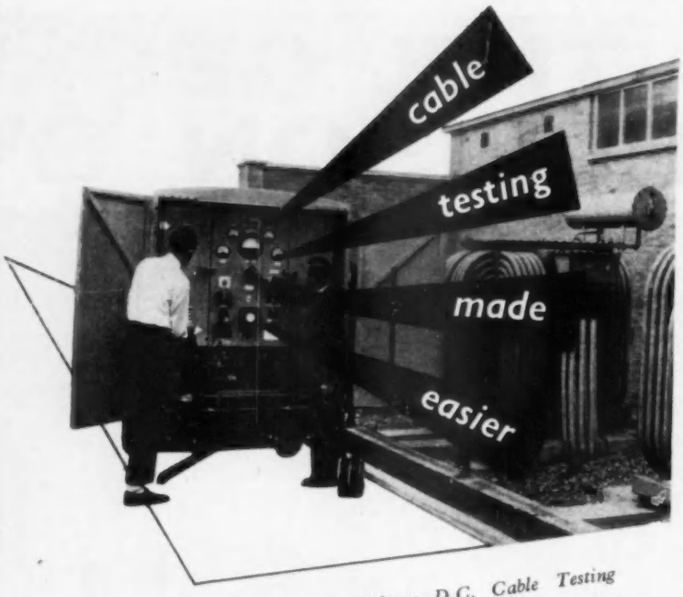

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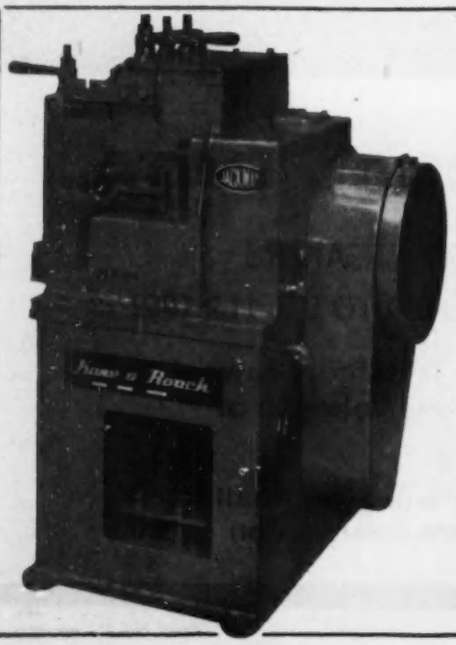

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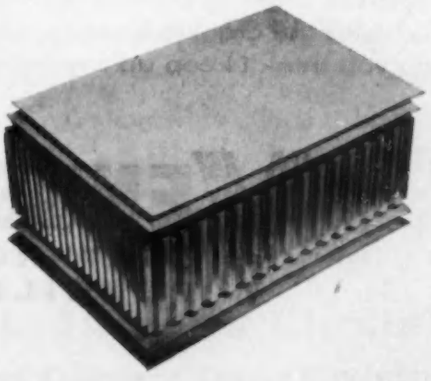

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and flow smoothly throughout a long line –
no crumbling or 'clinkers' mark you! –
and if I erase a line it must go cleanly –
there's no 'furrow' left in my paper
so you won't find ghost lines in prints
made off my drawings. As a matter of
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my drawing – the print's always first class."

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"Venus drawing pencils of course, the ones
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do you think I keep up my high standard?"

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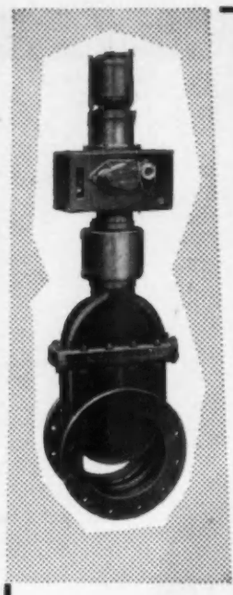

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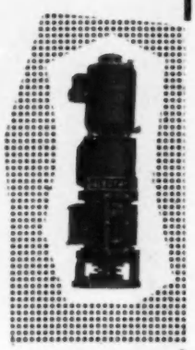

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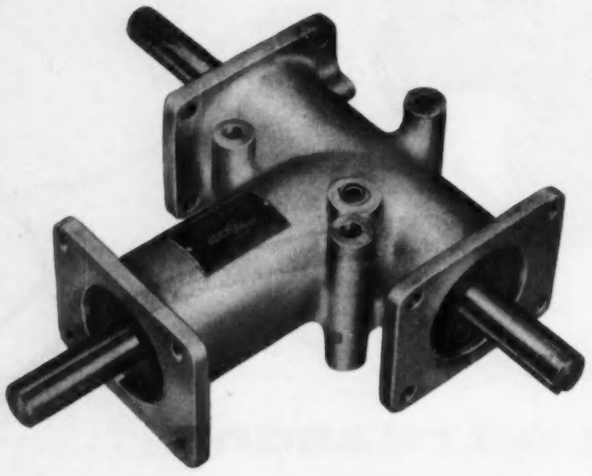

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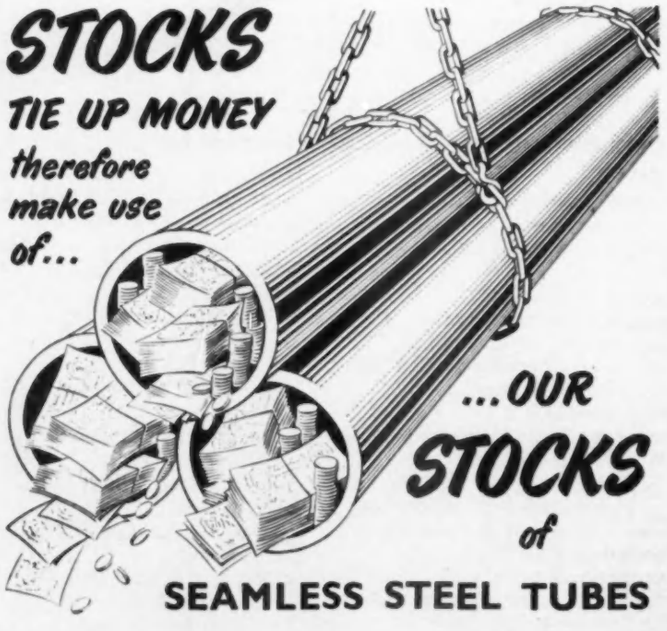

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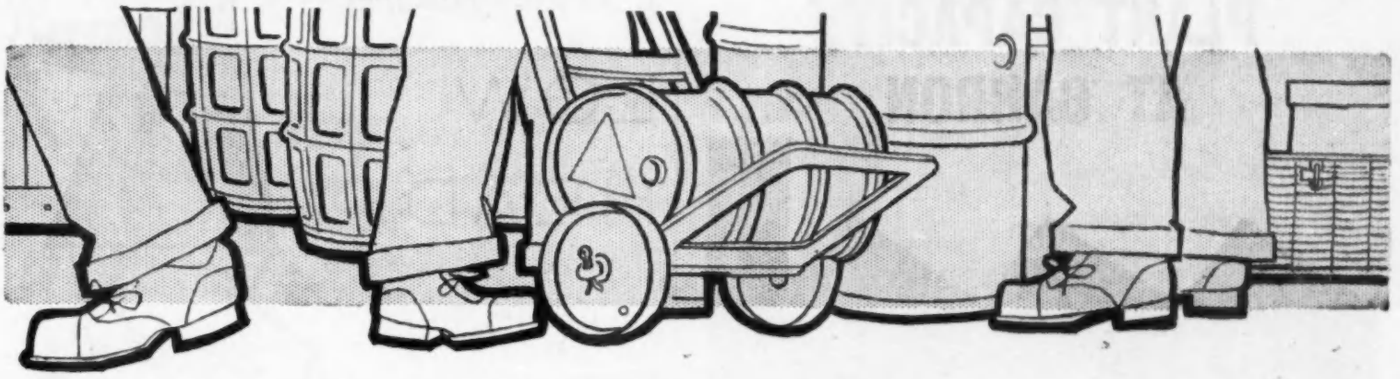

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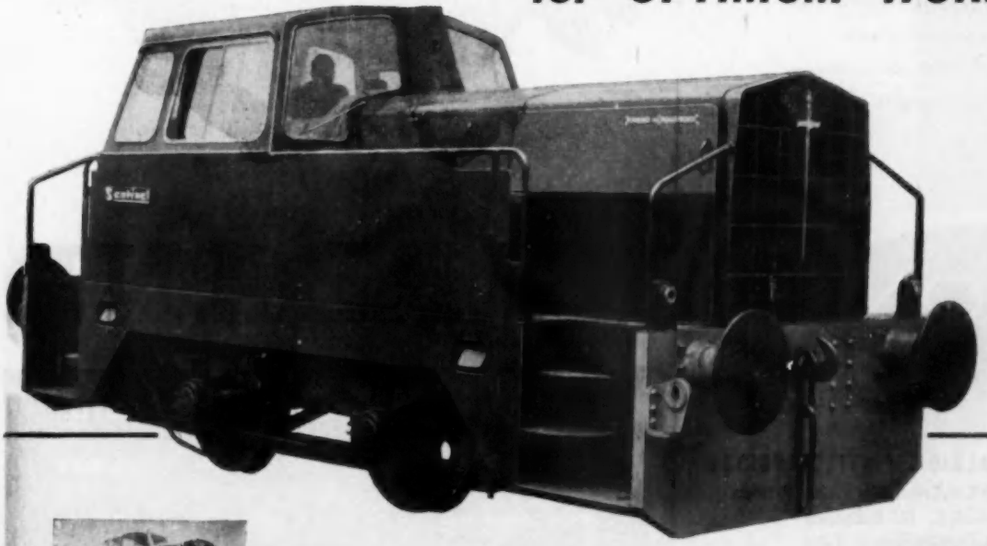
POWERED BY ROLLS-ROYCE Diesels

for OPTIMUM WORKING EFFICIENCY



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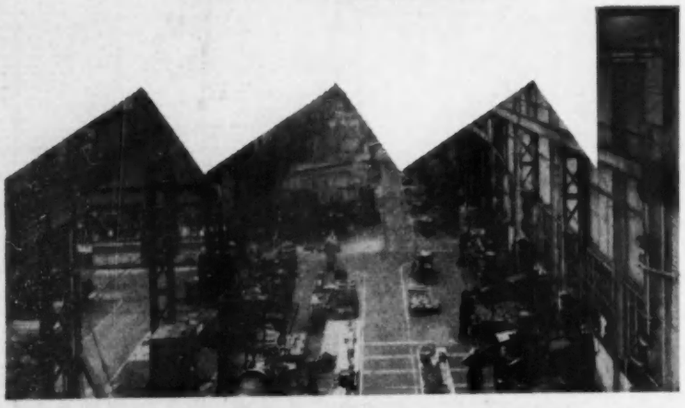

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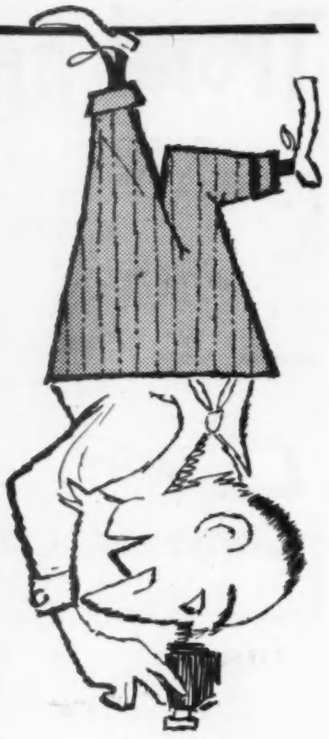

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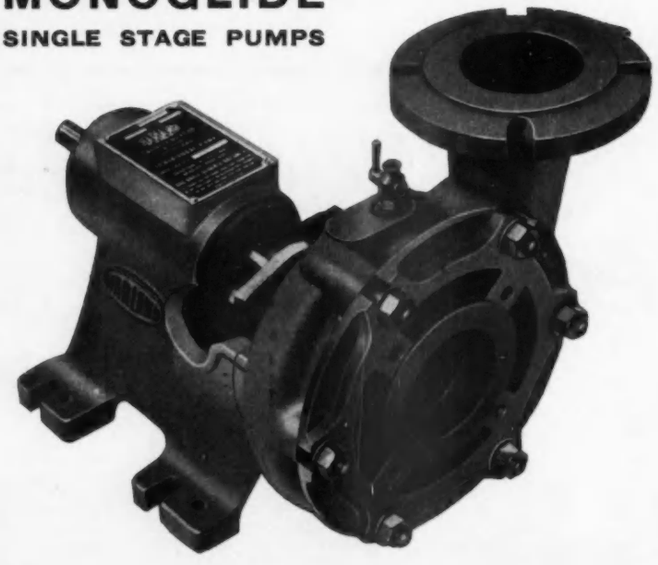

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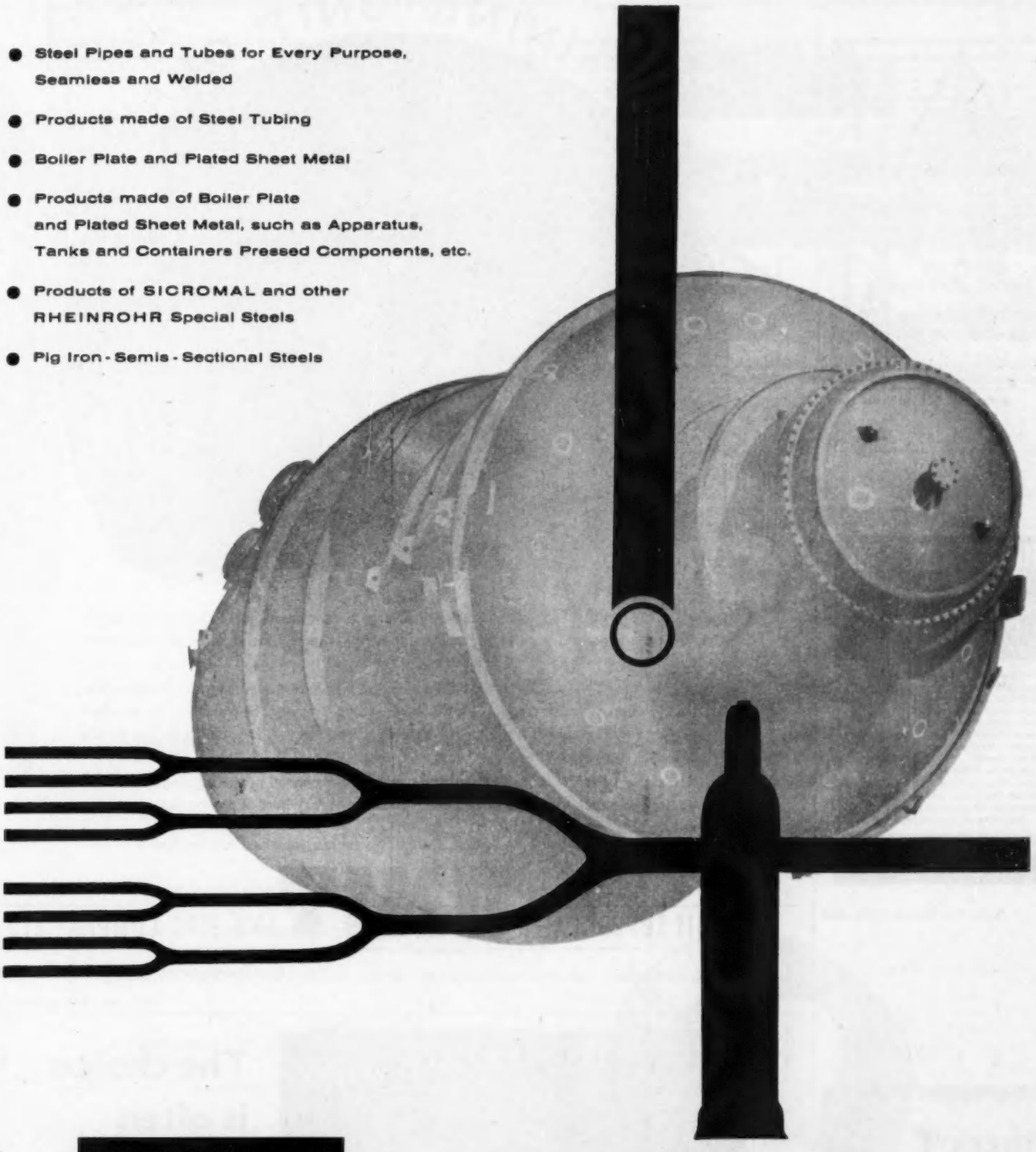

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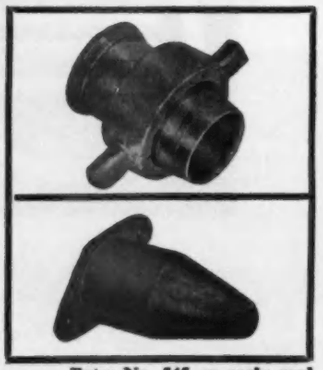

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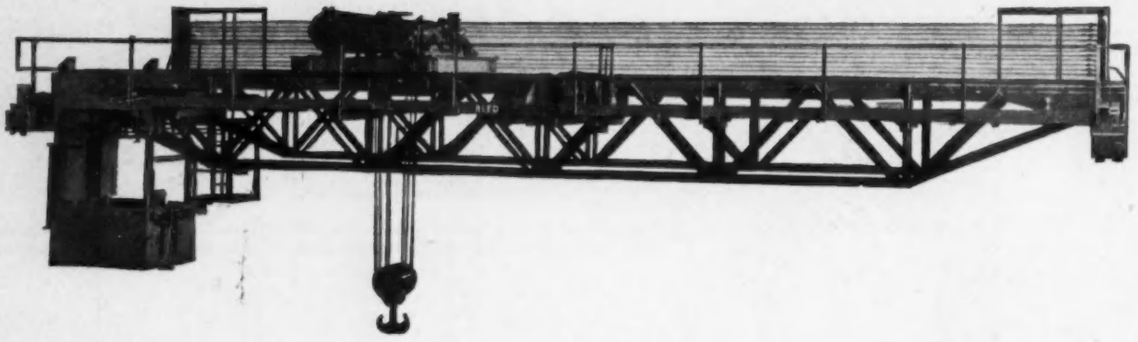

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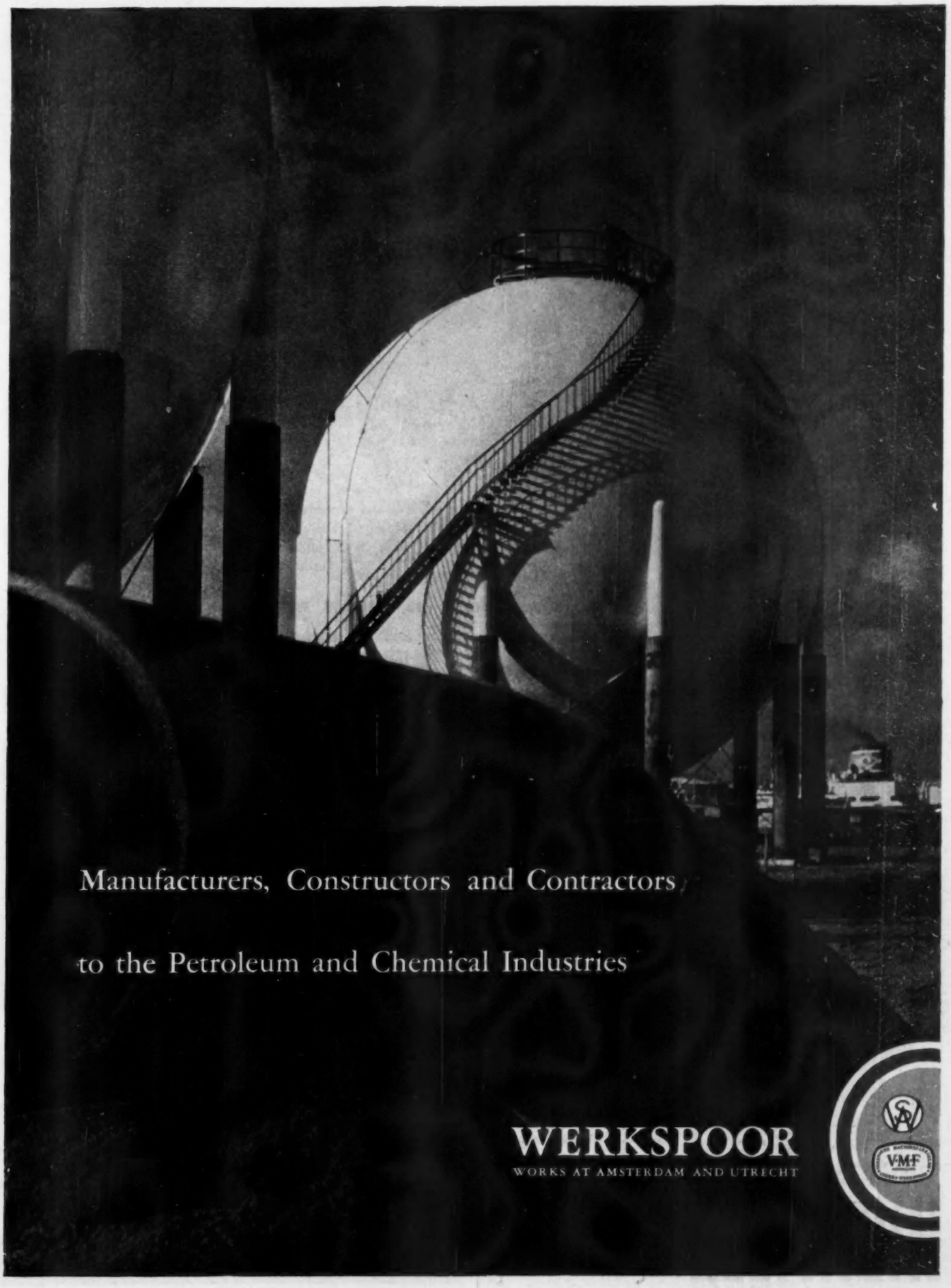
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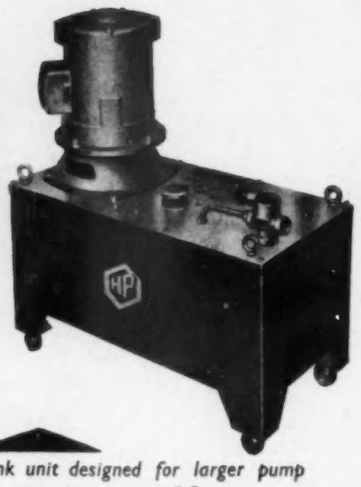

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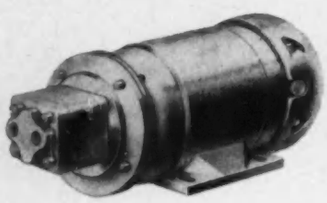

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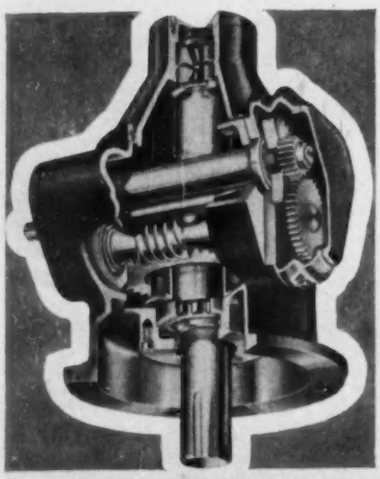

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Electrical Aids in Industry *Data Sheet* **No. 12**

Dielectric Heating - 3

Some further details of the uses to which dielectric heating can be put are given in this data sheet, being continued from data sheet No. 11.

The Woodworking Industry

A most important development in recent years in the woodworking industry has been the introduction of synthetic resin adhesives of the thermosetting type for the bonding and adhesion of wooden components.

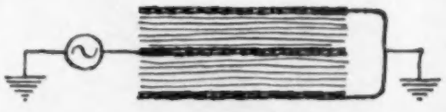
Setting of these resin adhesives proceeds at a rate largely determined by temperature. For instance, urea formaldehyde, one of the resins in common use, sets as follows :

TEMPERATURE	SETTING TIME
65°F	3 hours
80°F	1 hour
150°F	3 minutes
190°F	1 minute

The resultant bonded joint is equally satisfactory in each case. Most of the power supplied when dielectric heating is used is absorbed by the resin, the heat thus being concentrated where required and power consumption reduced to a minimum.

Plywood

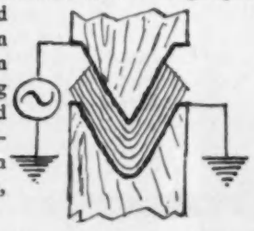
With dielectric heating consuming power only during the heating cycle, plywood can be produced with considerable savings in heating times and costs.



For example, in a press holding 100 3-ply ½" thick assemblies, the resin glue is set in 20 to 30 minutes, depending upon the dryness of the wood. An output of up to 60 cu. ft. of plywood is obtained per hour using a 25 kW H.F. generator.

Curved Laminated Sections

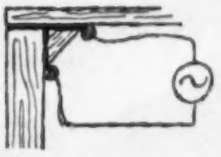
Curved laminated sections are being increasingly used in contemporary furniture, and with dielectric heating rapid production can be achieved using wooden shaping blocks in single daylight presses. An alternative method of providing heat by conduction from heated metal strips becomes increasingly slower as the total section thickness rises above 0.05 inch, as shown below:



TOTAL THICKNESS OF LAMINATIONS	*Comparative heating times in minutes*	
	CONDUCTION	DIELECTRIC
1 inch	20	4
¾ inch	5½	2½
0.6 mm veneer	1	1½

Furniture Assembly

Because of the savings in glueing processes already instanced, dielectric heating is being extensively used in the furniture trade. It leads also to reductions in labour and floor space, with the elimination of assembly jigs. The heating equipment can be placed directly in the production line, cutting handling to a minimum.



Resin-bonded Wood Chipboard

A substitute for natural timber is made from wood waste and chippings, broken down to a coarse size, mixed with synthetic resin and heated under pressure. Dielectric heating gives quick and uniform heating, and increased fluidity reduces the power required for the final pressing and curing operation. In a continuous process, the length of the press required is also reduced.

Blockboard

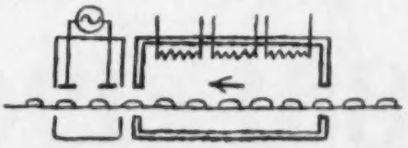
Production of blockboard by edge glueing strips of wood also provides an excellent use for dielectric heating, since considerable savings in time and labour can be effected owing to the large areas of glue line involved.

Other Resin-bonded Products

Dielectric heating is also used in the manufacture of other resin-bonded or impregnated products such as grinding wheels, impregnated woods, fabrics, felts, glass-fibre and similar products.

Foodstuffs

Increased use is being made of dielectric heating in many processes connected with foods; these include de-freezing and melting, sterilisation and disinfestation, drying of breakfast cereals, dog biscuits, rusks, etc., heating of nuts to facilitate shelling and other similar types of application. Although some cooking processes are technically possible, as for example bread baking, the 'unbrowned' product has so far proved unacceptable to the public and a completely dielectric process uneconomical. When combined with conventional baking, however, as now in the biscuit trade,



where dielectric heating is being used to complete the baking of biscuits, it can produce normal biscuits in ⅓ to ½ the usual baking time.

There are in fact so many potential applications of dielectric heating (and these applications are increasing daily as the chemical industry develops new products, as for example synthetic fibres) that the selection given in the present series of data sheets covers only a part of the whole field.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available — "Induction and Dielectric Heating" is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

7168/1

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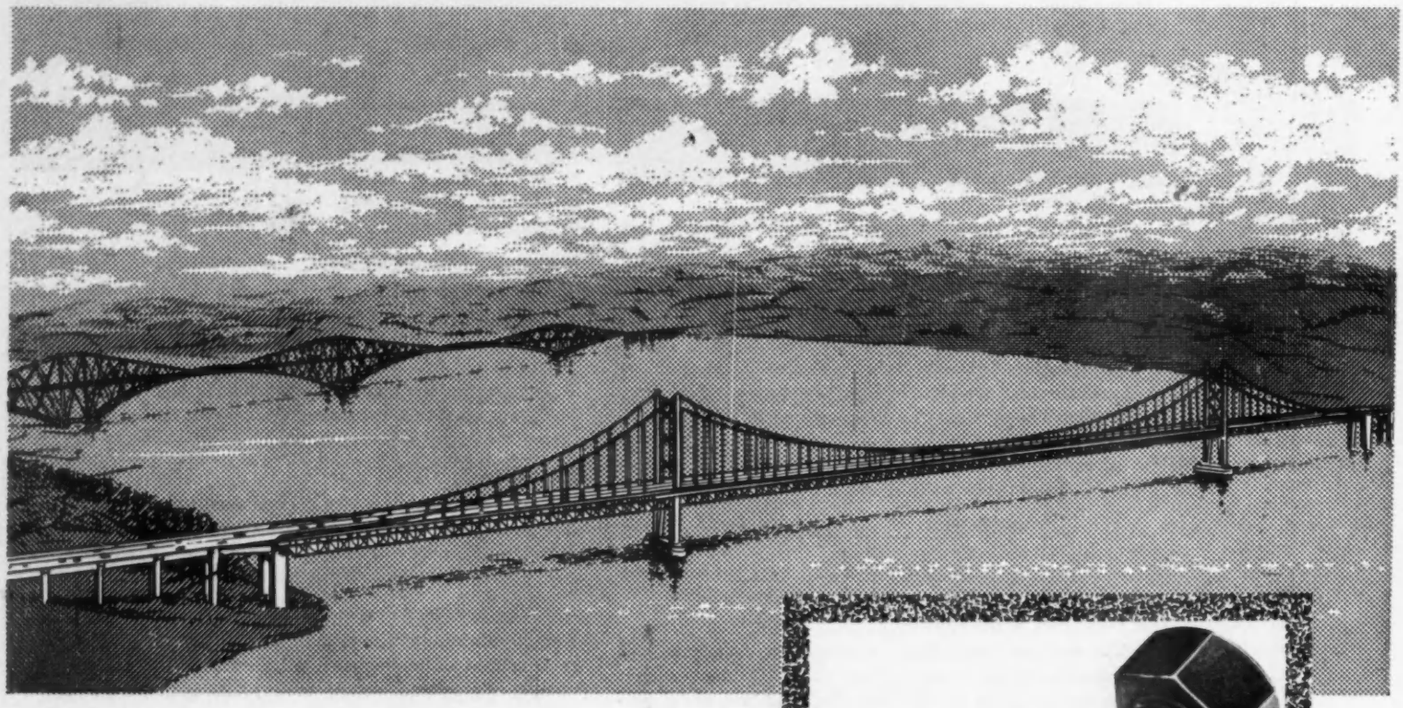

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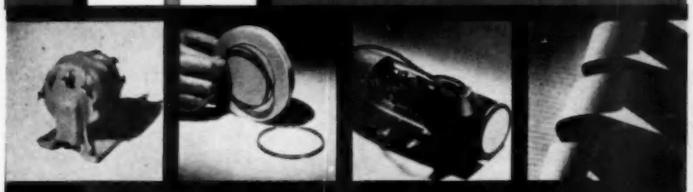

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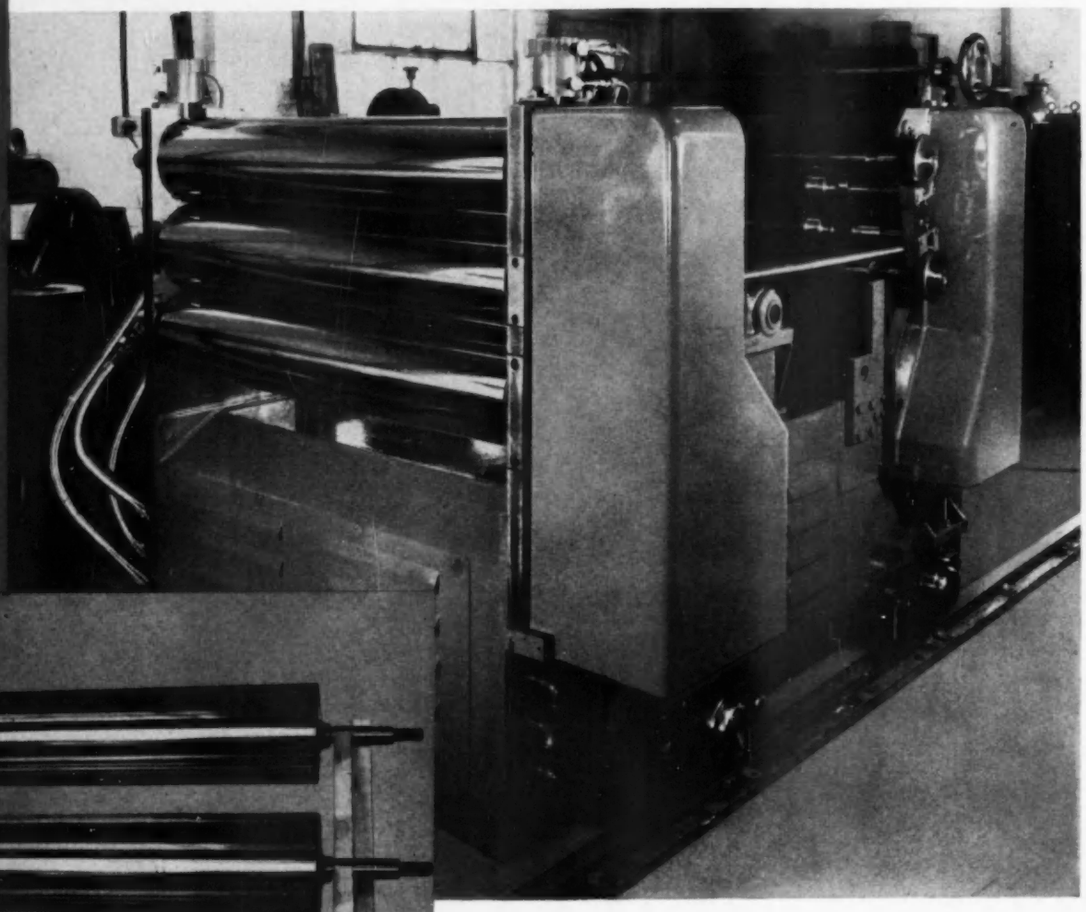

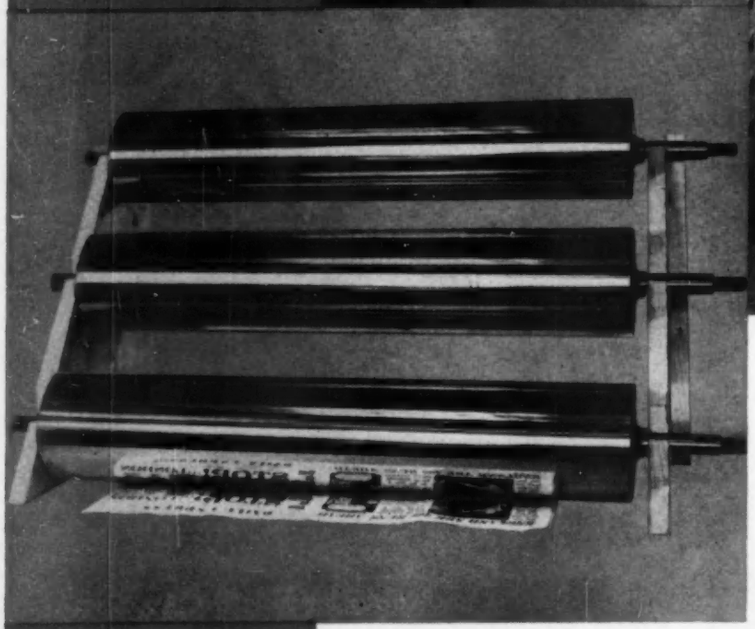

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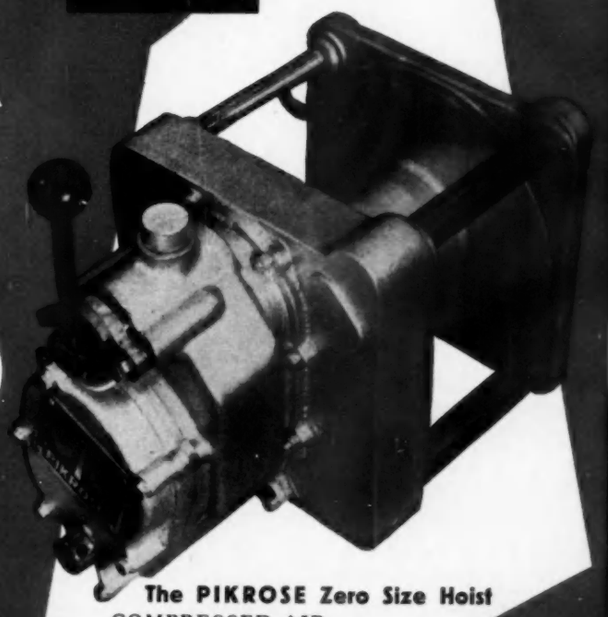

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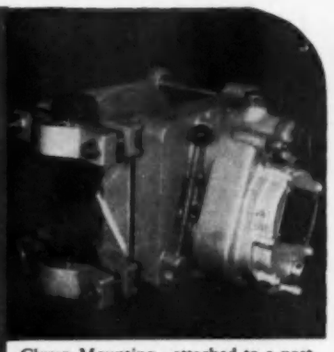
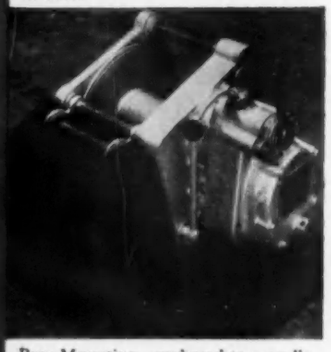


Clamp Mounting—attached to a post or davit.



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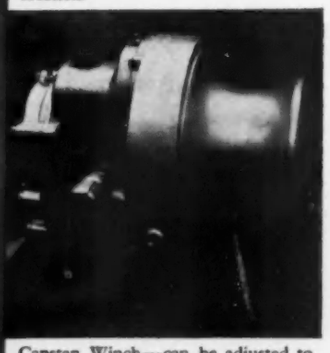

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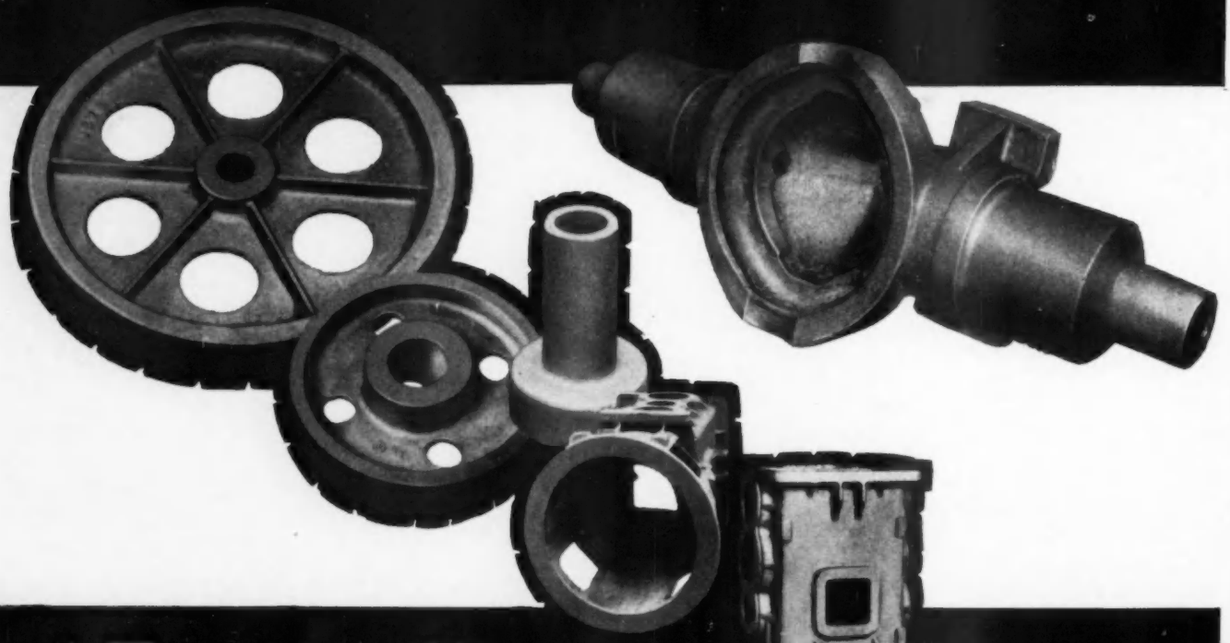

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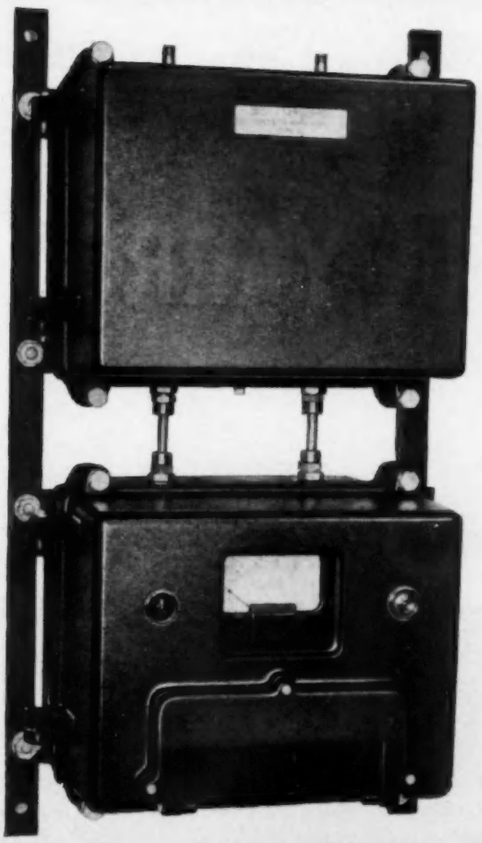

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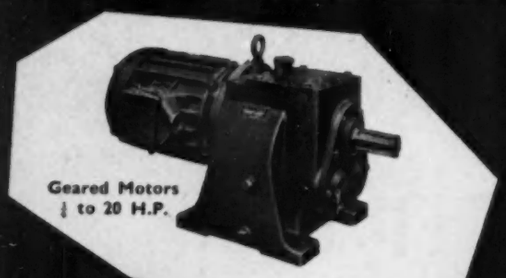

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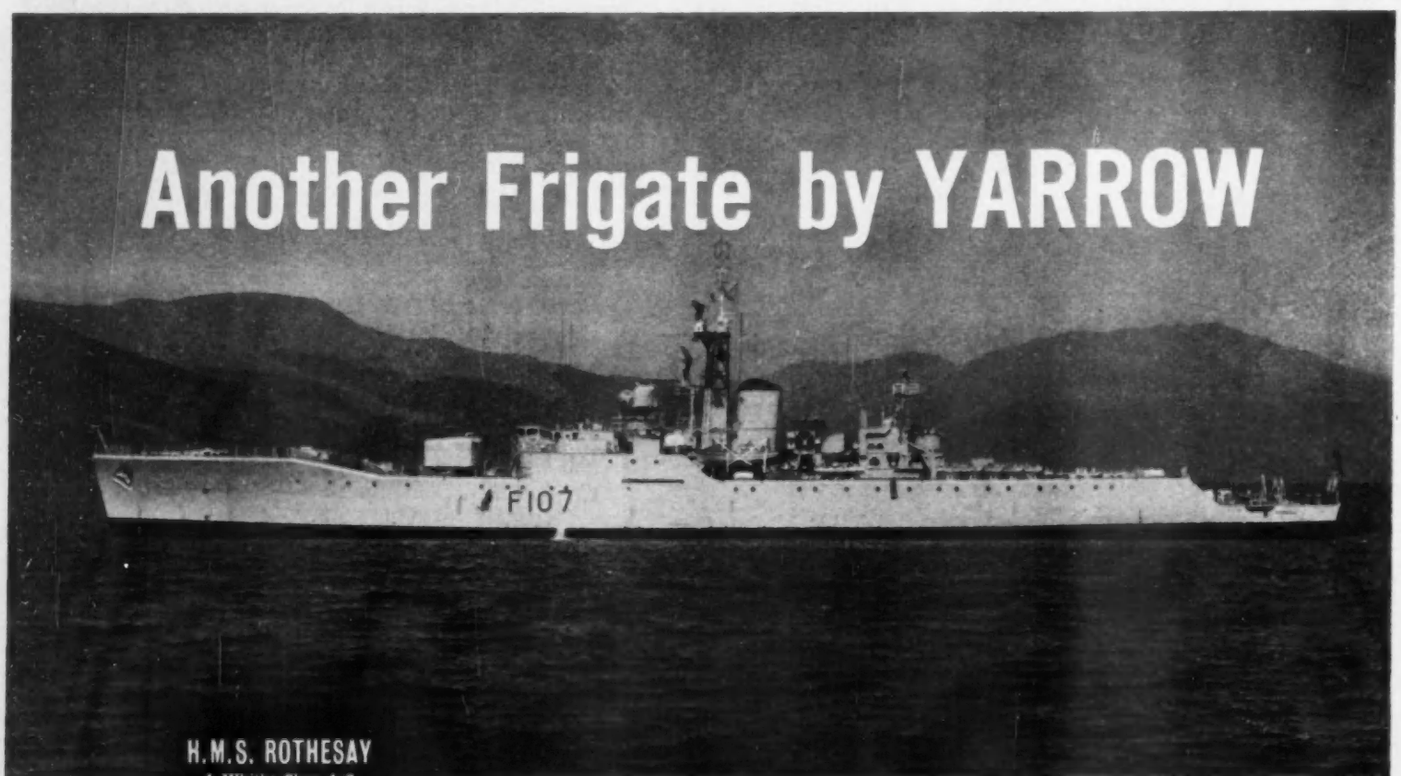

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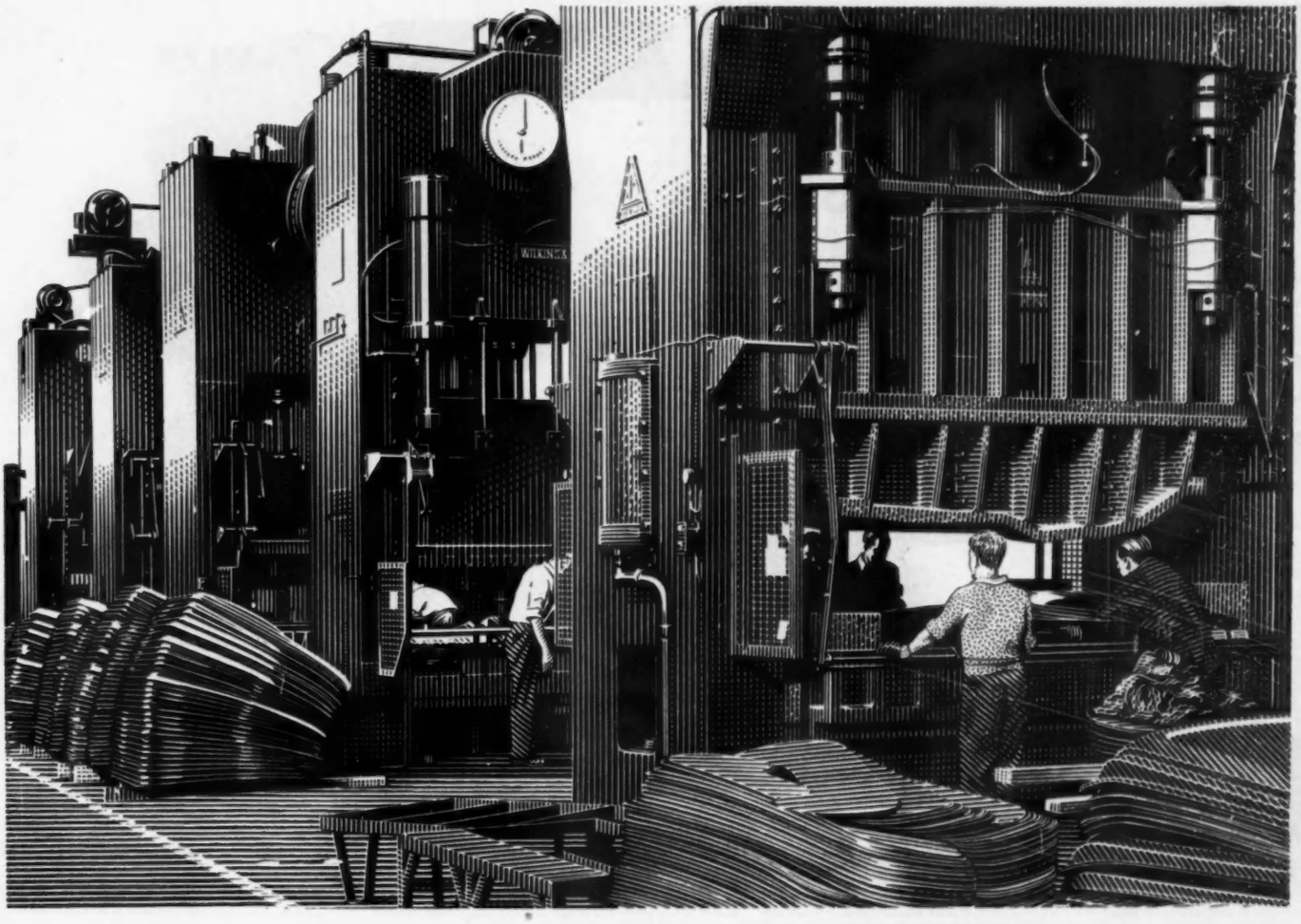

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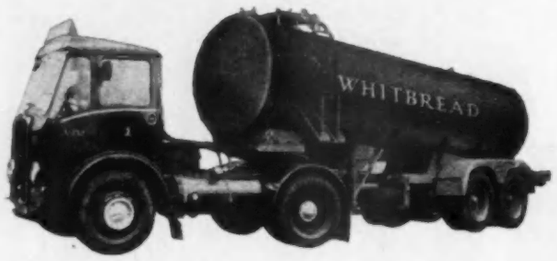

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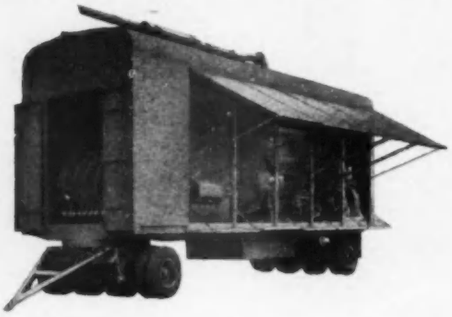

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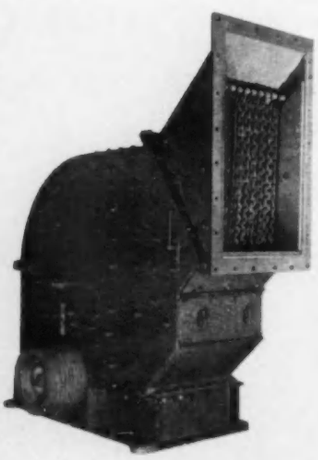

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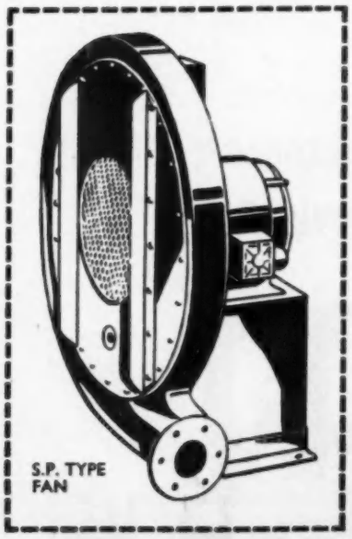

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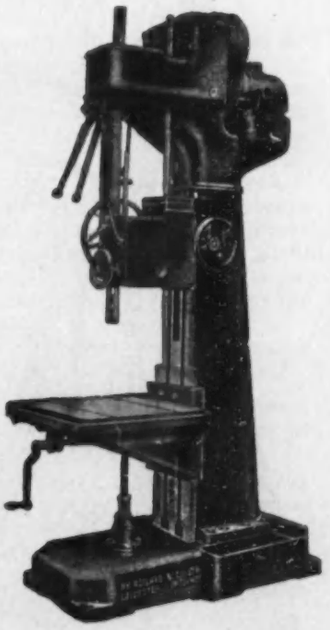

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Coal sews things up

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At the vast Singer factory at Clydebank in Scotland,

for Singer

chain grate stokers feed a moving belt of heat under the 4 giant boilers in the impressive powerhouse. The fuel is coal – chosen by the directors for reasons of convenience, economy and reliability. The choice is a wise one, for coal, mechanically stoked is smokeless, and produces more heat for the money than any other fuel. Furthermore, the coalfields of Britain can supply all the fuel our industries will need for scores of years to come.

Whether your own industry is big or small – remember Singer. Coal sewed up their fuel problems: the pattern is one you could copy with profit.

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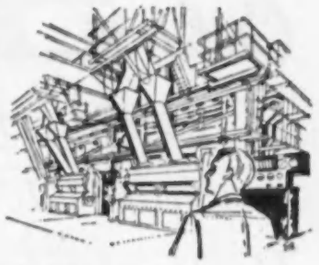

Coal generates power at Singer's Clydebank Factory

Mr. C. H. Fielding, Power Station Superintendent, comments:

"At Singer we provide our own power and steam process requirements from coal.

Two large boilers were installed in 1928 and a further two in 1950. Each has a continuous rating of 60,000 lbs. per hour.

The factory also has a large woodworking department, and the considerable quantities of wood chips and sawdust which have to be disposed of are burned in the boiler furnaces along with coal. Coal and ash handling presents no problem here. The boiler fans and the sawdust control equipment are driven by variable speed motors. Control is simple.

The designed efficiency of the boilers and economisers is 84% and they are operated between one annual overhaul and the next with nothing more than the normal maintenance. Their availability is high.

The quality of coal received is always consistent, its properties being regularly checked in the laboratory. Around 48,000 tons of coal and 4,000 tons of wood chips and sawdust are now consumed each year in the boilers.

We at Singer choose coal because it meets all our fuel requirements."

Here are some key facts and figures about the consumption of coal at Singer:

Number of boilers: ..... 4 water tube
Method of firing: ..... Chain Grate stokers
Steam pressure: ..... 360 lbs. per square inch
Continuous max. rating ..... 60,000 lbs. of steam per hour each
Steam pressure: ..... 725° F.
Feed temperature: ..... 185° F.
Annual fuel consumption: .. 48,000 tons of coal

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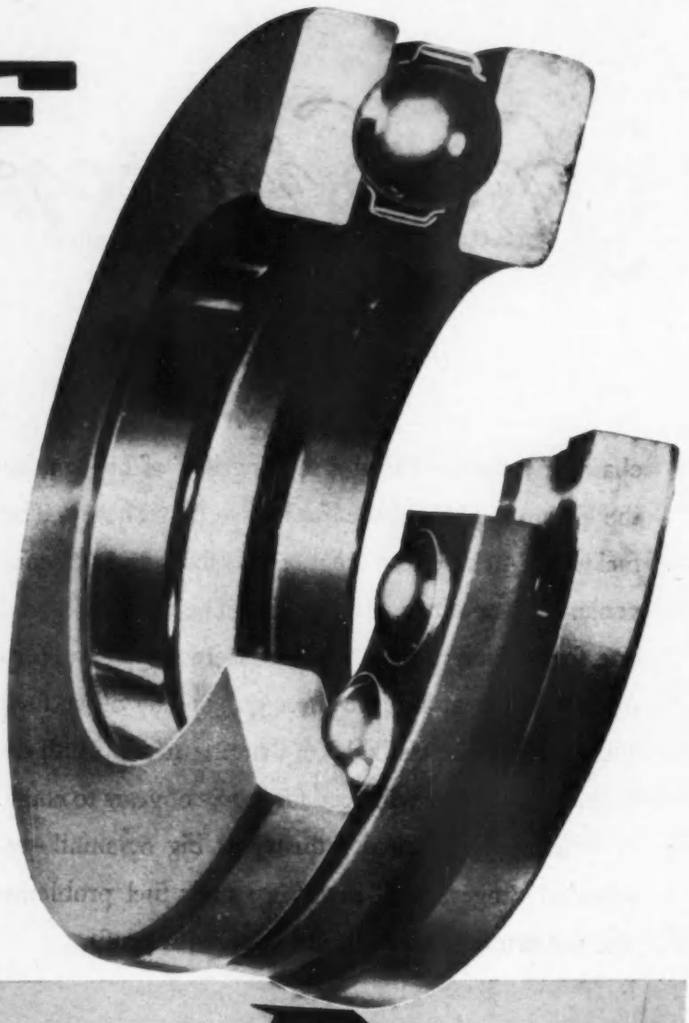

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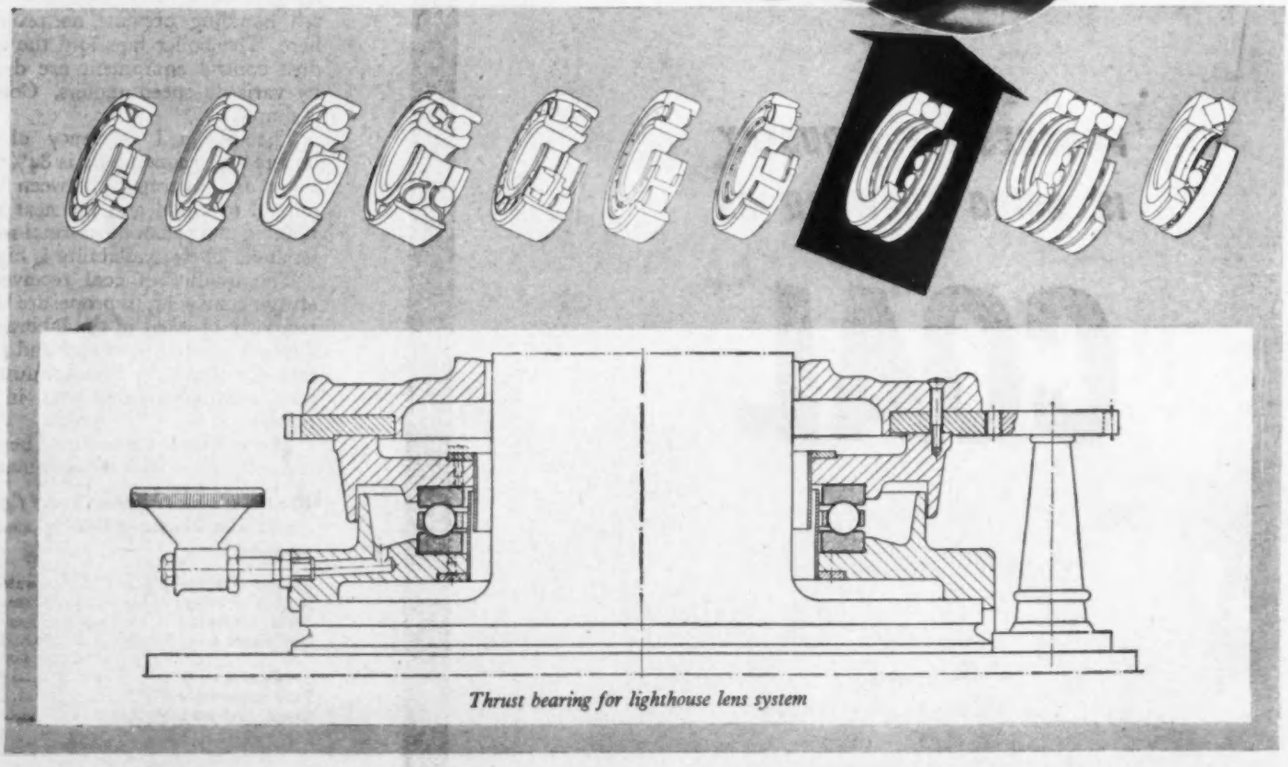

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THE ENGINEER

No. 5460 SEPTEMBER 16, 1960 Vol. 210

ENGINEERS AT THE BRITISH ASSOCIATION

As far as engineers were concerned the meeting at Cardiff of the British Association for the Advancement of Science got off to what a small boy would have called a "smashing" start. The President of the Association threw bouquets to engineers. "To me science without technology is incomplete and inconclusive." Sir Alfred Pugsley, President of Section G—Engineering, presented a quite outstanding address to that Section. Thereafter some very good papers of their kind were presented before the Section. But we continue to wonder — we have expressed the doubt before — whether Section G papers are all of the right kind and whether there are not papers of some other kind which could more appropriately be presented. The first point to be made is that, of course, the Section cannot hope to compete for the kinds of papers which are read at the major engineering institutions. No author of a first class research paper, for example, will desire to present it before Section G rather than before an institution. The reason is that the audience at a B.A. meeting is not a specialist one and is therefore not capable of discussing it properly even if it can be safely assumed (which is in doubt) that it would understand it. What can be done, and is in fact being done, is to get prominent engineers to attend the meetings and to tell the members about the work they are doing. The aim here is to get "lecturers" rather than "readers of papers" and to have "questions" afterwards rather than a "discussion". Additionally it is desirable and appropriate that something should be said about the engineering work being done at the university or technical college within the region in which the meeting is being held.

Both the kinds of contributions to the Section proceedings so far mentioned fall to be made by engineers for engineers. But the Section should surely also take note, somehow, of the changed emphasis of the whole of the work of the Association in recent years. More and more the British Association sees its role as that of explaining science to intelligent laymen and of transmitting scientific information across specialist frontiers from one science to another. It is in an attempt to help on that latter purpose of the Association that this year, as last year, our report, appearing in this issue, on the meeting of the Association at Cardiff is by no means confined to the proceedings of Section G alone but includes comment and reflection about papers read before other Sections. Engineering is a technology. That makes Section G an odd one out amongst the other Sections, which are predominately scientific, though several of them, including Section B—Chemistry and Section M—Agriculture, have close connections with technology. The point is important because scientists and technologists do not think along quite the same lines. It is relatively easy to put some of the wider scientific generalisations across to an intelligent audience and it is even possible to discuss the bearing of quite detailed evidence upon such generalisations in a manner intelligible to the non-specialist. But when engineers come to apply these apparently simple generalisations they usually turn out to be much less simple than they seem and resort has to be had to detailed mathematical investigations and to practical experiment. It is far from easy to put this kind of material across to a lay audience. Sir Alfred Pugsley, having acquired the art of exposition to a very high degree made it look deceptively easy. Yet such a kind of paper is peculiarly appropriate for presentation before Section G. We hasten to add that they quite often figure in its proceedings.

But though engineering is the odd one out amongst the Sections at a B.A. meeting, it does seem to have the opportunity, more than any other Section, to act, as it were, as a cement linking all the rest together. For engineering influences in some way, and is in turn influenced in some way by, each of the sciences represented by other Sections. That assertion is clearly true of Sections A, B, C, F, L, M, and N, Physics, Chemistry, Geology, Economics, Education, Agriculture and Sociology. It is true, too, of Section E—Geography which often studies aspects of industrialisation. About Section D—Zoology we need mention only that several years ago engineers attending the Conversazione of the Royal Society were deeply intrigued by a mechanical model illustrating the mechanism by which insects vibrate their wings. Year by year we find it desirable to comment upon the activities of Sections I—Physiology and J—Psychology because of some relationship of their work to that of engineers. Section K—Botany includes Forestry for which a number of engineering devices are used and which has influence of interest for engineers on, for example, the regimes of rivers. Section H—Anthropology covers the structures of ancient buildings. We would like to see at B.A. meetings more people from other Sections invited to give papers before Section G, more joint meetings of that Section with other Sections and more encouragement given to engineers to present papers to other Sections.

MORE ABOUT FARNBOROUGH

We discussed last week the customers who could be assumed to be assembled at Farnborough for the exhibition and flying display of the Society of British Aircraft Constructors. Perhaps the one thing that all of them must have shared is curiosity and wonderment at the cataclysm that has shattered great and apparently well-integrated firms. Quite clearly, the industry of today can be likened to none other that has ever been seen in any of the accepted aircraft-building countries, except that in Western Germany where numerous embattled and impoverished firms have joined forces to insure survival in a fearsomely adverse environment. But this does not mean that history can be of no value in seeking to understand the causes and effects of the transmutation we have witnessed. In fact, coming events can be seen casting shadows long before in the little book "Bristol Fashion" that has just been

written by John Pudney to preserve, before they disappear from living memories, some record of the pioneers of aviation in Great Britain and the West Country in particular. The pages are peopled with characters who contributed much to building up British aviation to be a potent factor in world affairs — Sir George and Sir Stanley White, Sir Sefton Brancker, Sir Roy Fedden, and Frank Barnwell, who has impressed the author principally by his inadequacies as a pilot. But it is recorded that a man with no official or commercial connection with aviation, Harold Sidney Harmsworth, first Viscount Rothermere, played a part little less than vital in the critical years before 1939. Lord Rothermere realised the consequences of the fact that the industry was engaged in "producing the obsolete", and determined, as a practical criticism of the Air Ministry to have built the fastest commercial aircraft in Europe within one year of placing his order. It was pointed out to him that the Bristol Aeroplane Company was the largest single unit building aeroplanes and engines in the world, and he sent to the company an invitation to build the world's fastest civil aeroplane at his expense. But the Bristol Aeroplane Company showed the opposite of enthusiasm: they explained that "while (Lord Rothermere's) criticisms were true, they could not be a party to offending their best if not only customer." An attitude so amoral would in fiction presage disaster, and in fact the company has tragically failed to fufil its destiny.

What then does the future hold for the industry? Perhaps never before have so many of the manufacturers been unknown quantities to their visitors at Farnborough, who in self-protection must be alert to discover which of the constructors are based on lasting foundations of finance, research, recruitment and management, and which are merely playthings of the continual change that characterises the industry. Certainly in some cases reserve is appropriate: there is some trading on the hope that two small wind tunnels will test a large model, and that two £2,500 men can fill a £5,000 post. One trend must rouse misgivings, being as it is the natural result of the sudden lessening of competition, and that is the tendency to take chances of falling short rather than of exceeding expectations. That the first British compound engines in commercial service might be less than flawless was perhaps unavoidable in view of the destruction of the R.A.F. machines that should have flown with them, but delays in developing a turbo-prop engine should hardly arise at the stage of flight testing a new aircraft when there have for long been available airframes, such as the Saro "Princess", capable of testing four or even six engines without risk. At the same time one sees capital being tied up in aircraft much like ones remembered from Farnborough three years ago, but nothing more than paper aeroplanes have appeared embodying boundary layer control for low drag. It now appears very probable that history will repeat itself and that Northrop, which carried to its ultimate the rear engine position now widely advocated in this country, will be the first to exploit artificially sustained laminar flow.

HEALTH AND THE ENGINEER

Almost every form of industrial activity has its hazards, which can be divided into two broad categories, the mechanical and the non-mechanical. The mechanical, that is the risk of injury from machinery of all kinds, was the first to be recognised and guarded against, and a very high standard of safety in this respect is rightly enforced by law in this country. This mechanical category is very much the concern of the engineer. The second, non-mechanical class of hazard is often much more difficult to deal with, and can only be combated successfully, as a rule, by co-operation, between engineers and workers in other professions. In some of the newer industries and processes the non-mechanical hazard is obvious, as for example, in the use of radio-active materials. These newer industries had, of necessity, comprehensive safety and health precautions built in from the start. That such industries should have investigated the potential hazards so thoroughly and enforced such stringent precautions occasions no surprise. What is surprising is the slowness with which industry generally is accepting the idea that occupational hazards are by no means confined to the more immediately obvious processes. In some industries, of course, great care is taken to ensure that workers do not come into contact with dangerous gases, liquids or dusts, but the sources and extent of the danger may not be evident until the whole working environment is investigated.

In the matter of investigating possible hazards there appear to be difficulties. When the Slough Industrial Health Service (to which reference is made elsewhere in this issue) decided a few years ago to start an occupational hygiene section, it was found that there were no facilities in this country for giving specialised training to engineers in this field. There are, in fact, still no such facilities. An occupational hygiene engineer must be, basically, a mechanical engineer, but he has to work in close co-operation with physicians and chemists, and his training must be such that he can see their points of view. In the U.S.A. occupational hygiene engineering has been developed much more fully, and it was to that country that the Slough engineer (already qualified in the mechanical branch) was sent for his specialised training.

If occupational hygiene engineering is to make progress in this country, two things are essential; industry must recognise its value, and specialised training facilities must be made available. It is universally recognised that workers must be protected, as far as is humanly possible, from the dangers of machinery. But there are often other dangers in industry. A worker may be subjected to physical risks, frequently more insidious, from gases or dusts. His health may suffer from the effects of bad lighting or ventilation, heat or noise. Investigation of these matters is the work of the occupational hygiene engineer and his medical colleagues. If the work is to be extended — and the experience of the occupational hygiene unit at Slough shows that industry is now beginning to appreciate the need for environmental investigation — means for training engineers specially for the work will be needed. If suitable facilities are not provided, industry may well find itself suffering from yet another of the shortages of skilled workers which plague it from time to time.

KEEPING RESEARCH IN TOUCH WITH NEEDS

The recently issued annual report of the British Welding Research Association contains an interesting note on a "research priorities survey" which has been carried out. For this survey all members of the association were sent an outline of the present and proposed future research programme for the five years 1959-64 and an official representative of each member firm was asked to indicate, on a points award system, his company's views regarding individual priorities according to importance. Sixty per cent of the members, representing eighty-five per cent of the total subscription income, responded to

this invitation. The survey showed that the importance of the projects being currently investigated as assessed by members was very similar to the allocation of funds by the Research Board. But some forty-five per cent of the points were allocated to projects listed under the future programme and which had not been started.

A survey such as this not only gives the members of an association an opportunity to indicate their preferences but also gives the association a comprehensive collective idea of the required trend in future research. In other words those responsible for research are given an indication of the general trend which their practical work should follow in the best interests of the industry they serve. Further, by analysis of the responses collective and associated projects can be developed where possibly individual lines suited to restricted numbers of members would otherwise have been contemplated.

As its annual reports have shown the B.W.R.A. has always been a progressive body and in adopting this method of ascertaining the needs of its members it has undoubtedly ensured the value of its future work. We do not know how many other industrial research associations follow this priorities survey procedure, but many of them, outside fundamental research, are mainly concerned with investigations inspired by individual members. The more widespread use of priority surveys amongst members would, we feel, keep research laboratories more fully informed of current industrial needs and be of considerable assistance when planning future work with a view to its being of the fullest benefit to the greatest number of members.

GAS EXPLOSIONS IN MINES

The recently issued annual report of the Safety in Mines Research Establishment and that of the Chief Inspector of Mines and Quarries both mention that the freedom from fatal explosions and fires in mines in the previous year was not maintained in 1959 and sixteen lives were lost as a result of explosions of firedamp or dust. Indeed the S.M.R.E. report states that, although in the last thirty years the explosion hazard has become less severe, the annual number of gas explosions has not changed significantly in the last nine years. The lessening of the hazard can be attributed to a reduction in the extent and violence of explosions rather than in their number. The chief inspector's report says that a disturbing feature too commonly found in investigation of explosions is that the gas had not been detected near the site of the explosion before the occurrence of the accident.

In his remarks that he was forced to the conclusion that the standard of inspection by some officials was simply not good enough during the year, the inspector, although probably right, may be somewhat severe on officials who have many conflicting duties. Might it not be suggested that effective instrumentation could be introduced not necessarily to replace but to supplement the fallible human element in the important work of detecting firedamp. A multi-point continuous recording methanometer developed by the Mining Research Establishment should prove a valuable automatic means of giving advance warning of dangerous gas concentrations. This instrument is now being manufactured commercially and will, we understand, shortly be generally available. The sound understanding of the phenomenon of firedamp roof layers resulting from studies by the S.M.R.E. combined with efficient instrumentation might well lead to an effective reduction, if not a complete elimination, of the firedamp hazard.

HISTORIC VEHICLES

This week we once again had the pleasure of attending the annual rally of the Historic Commercial Vehicles Club. This year's event was even more interesting, both to the seeker for spectacle and the student of detail. It included a number of steamers. Both the exciting "over-type" and the deceptively conventional-seeming Sentinels snuffled and snorted in the sunlight. The motor vehicles were supplemented by two such contrasting exponents of the dead axle as a chain drive Scammell tractor and a 1922 De Dion Bouton road sweeper, freshly retired from active service at Menton and decorated, apparently, with selected sweepings. There can be little doubt that an assembly such as this must serve as a valuable warning to anyone tempted to think a single form of vehicle will be, let alone has been, evolved to suit all purposes. Perhaps particularly to be welcomed are the vehicles prepared by the apprentices; it must be a highly suitable start to a career in engineering to realise that forty or fifty years hence your work may be probed and dissected and analysed, and that the virtues and vices will be preserved long after the aspirations and excuses are forgotten.

The Engineer—100 Years Ago (SEPTEMBER 19, 1860)

"SOUTH KENSINGTON MUSEUM"

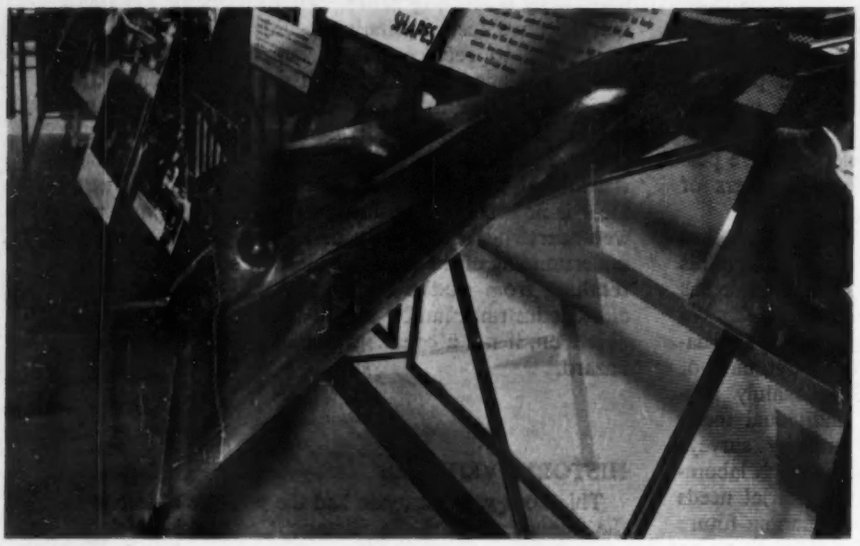
"The South Kensington Museum is not for London alone. A travelling collection bears about a thousand selected articles at a time to various towns, and gives them an opportunity of seeing the best examples. Witnesses from Sheffield bear testimony to the usefulness of this circulating exhibition in suggesting to them new forms of ornament, and aiding the study of art. There has been very great improvement in silver and plated manufacture, in Britannia metal and ironwork, and also in cutlery; in stoves, too, in which Sheffield has a very considerable trade. The improvement has been not merely in the design, but in the casting; the standard of elegance of form has been raised, and the artistic manipulation very much improved. A retired manufacturer at Sheffield says—'I think our ornamental castings would now compete with the beautiful designs of old Italian manufacture'—and, again—'Our art students at Sheffield have executed works in wood carving equal to the productions of any country that I have seen'; while the president of the School of Art is able to add—'We have had several young men who have risen from the ranks, who, had it not been for the school and the Department of Science and Art generally, would have been getting, perhaps, £2 a week as first-class workmen, but who are now getting their £200 or £300 a year.'

"A witness from Birmingham (Sir F. Scott) tells how greatly its brass and ironwork has been benefited by the travelling collection which is sent to that town every year. He says—'There is no one who knows his workmen personally, as I do, but must be aware how very much they are assisted in matters of art workmanship by the contemplation and study of such excellent things'; 'the manufacturers of Birmingham have very much improved in purity of design and beauty of outline within the last five or six years, which I attribute to the South Kensington Museum indirectly acting through our Birmingham School of Art'."

1960 S.B.A.C. Exhibition

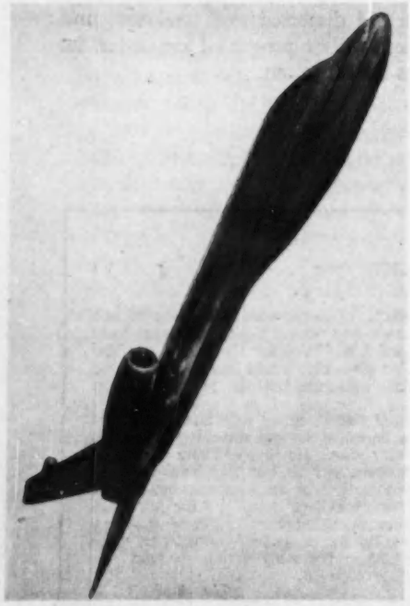
No. II—(*Concluded from page 424, September 9*)

The twenty-first Flying Display and Exhibition of the Society of British Aircraft Constructors was held last week at Farnborough. We continue below our account of some of the exhibits of technical interest.



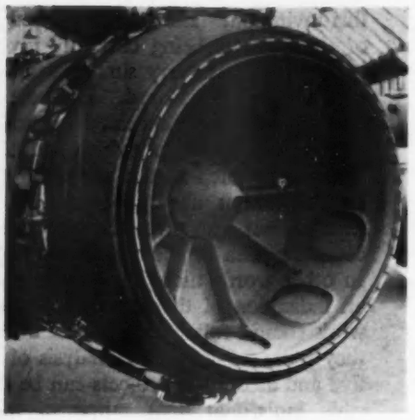
A model of the H.P.115 narrow delta

THERE were to be seen a number of models of projected aircraft, many of which were in no more than the project stage. Among the models illustrating tangible machines not at the exhibition was, however, the wooden wind-tunnel model illustrated of the Handley Page H.P.115. The configuration is, of course, a narrow delta; the section is thick and sharp-edged, without perceptible camber. The model has a downward-bulged nose reminiscent of that of a "Victor," but this may be merely because the H.P.115 itself is so small that the pilot demands a disproportionately large cabin. Also unlikely to be representative is the shape and position of the air intake; while the North American F.107 did have a dorsal intake, most studies favour integrating the lift and propulsion systems at least to the extent of putting the intakes on the high-pressure side of the wing. While the narrow delta planform has been ardently advocated for low drag supersonic flight at moderate Mach numbers, there has as yet been no demonstration that the configuration would be satisfactory in low speed flight, and this is the purpose for which the H.P.115 has been built. It should be borne in mind that one particular advantage cited by Handley Page for this configuration is that it should be but slightly sensitive to variations in Reynolds and Mach numbers, since the Mach number normal to the leading edge is at all times low, while the effect of Reynolds number is predominantly to influence separation which, on the narrow delta, at all times occurs at the leading edge. It appears probable that the handling qualities at high C_L—for instance, the magnitude of inertia terms in the pitching stability—will set a lower limit to the aspect ratio, apart from the difficulties of providing an undercarriage and accommodating extremely large changes in ground angle.



The sharp leading edge of the uncambered wing can be discerned

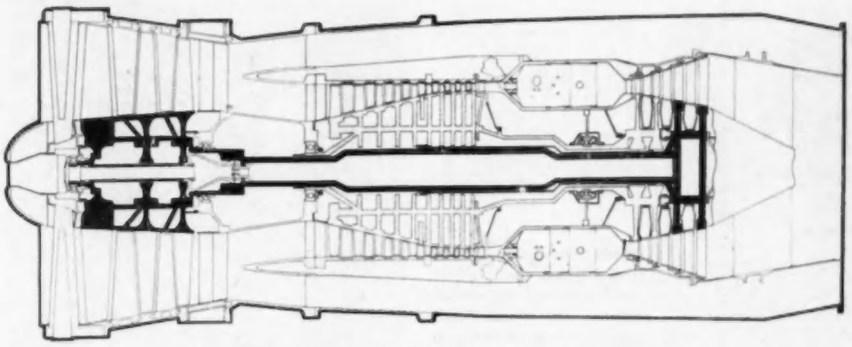
A small number of new engines appeared at the exhibition, including the Rolls-Royce RB-141, the first of the "second generation" of the bypass engines that are an exclusive product of Rolls-Royce, Ltd. The RB-141 gives 15,000 lb thrust, and is expected to replace the "Avon" turbojets in later versions of the Sud "Caravelle"; others, interestingly enough, will have G.E. CJ-805-23 turbofans, this being the only known case of by-pass and fan engines being made available in similar airframes. The engine, which, like the rather smaller RB-163, has a Smiths electrical fuel control is illustrated here; conspicuous is the device for mixing the cold and hot effluxes, which resembles in principle the silencer of an "Avon turbojet."



The ducts from both turbine and compressor were blanked off upstream of the mixing section of the RB - 141

Another engine optimised for civil operation, with considerable emphasis on the low weight demanded for rear engine installations, is the Bristol Siddeley BS-75 ducted fan of 7350 lb thrust and 1485 lb dry weight; this engine is still incomplete, but artist's impressions show a simple unit reminiscent of the R-R "Soar" of even lower specific weight. A section through the engine is reproduced opposite; it is noteworthy that power needed to drive the l.p. compressor has forced the l.p. turbine size up until it is the largest member of the basic engine, and a cannular combustion chamber can therefore be used. This, being a civil engine, is mechanically more conservative than the lift/thrust ducted fans of the same manufacturer, and it will be seen that the h.p. and l.p. turbines are each supported from the frame, with only sealing glands and, apparently, a bleed duct from the h.p. compressor fifth stage in between them. It is stated that a large number of the components "are identical or closely similar in design to" those of engines with thousands of hours in service, presumably the "Proteus" and/or "Olympus."

A new approach to one of the more important and, it has proved, difficult engine auxiliaries was shown by Plessey, Ltd., who are developing a constant speed alternator drive which functions also as a starter motor and is capable of driving the alternator from a ground power source without the main engine turning over. This new constant speed drive is, like the established designs, purely mechanical when the engine speed matches that of the alternator, but at other speeds power is fed in or tapped off by an air motor/pump—the latter is not a turbine but a positive displacement machine, with the result that in the matching condition it can carry its share of the torque without consuming any significant quantity of air. Further, it is claimed that this drive is "stiff," in the sense of suffering little phase change with alteration of load, while the low inertia of the positive displacement machine facilitates rapid control. The principle of the drive can be seen in our diagram; it will be clear that the epicyclic train allows the air motor to add to or subtract from the speed generated by the engine-driven gear train. When it is desired to start the engine, the motor must be prevented from driving only the generator, and this is done by moving to the right the simple clutch that can be discerned in the diagram until it locks the two sun wheels together. For ground running of the generator, it is disconnected from the

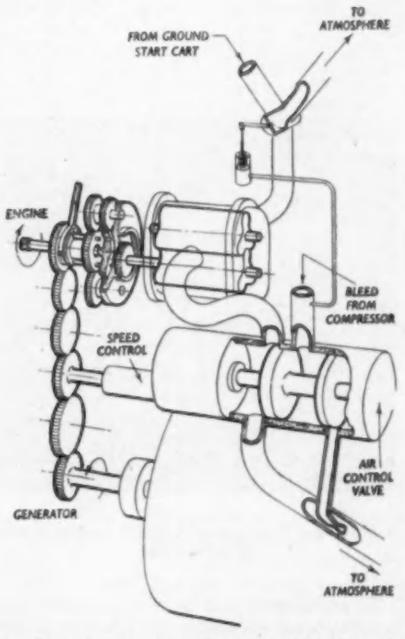


The BS-75 has a ratio of "cold" to "hot" flows of 1·6

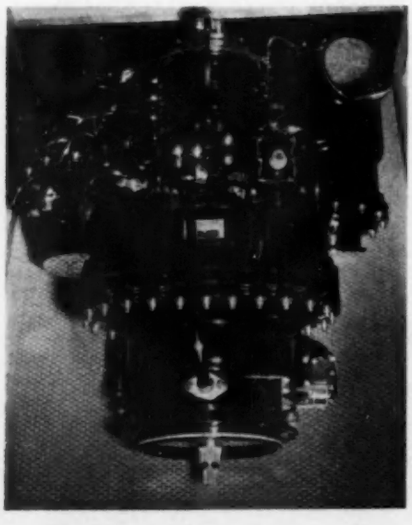
engine drive train. Close study of the diagram will show that the direction of running of the air motor for motoring is the same as that of the engine, while to increase the generator speed the motor is driven in the opposite direction. When the engine is running faster than the selected matching speed, the motor is allowed to act as a blower, and the diagram shows the air control valve in this position. It may be that, if the chosen matching point is at a speed well below the maximum, the power consumption of the pump is so high that it would not run up to a sufficiently high speed to prevent the generator over-speeding, and in this case compressor bleed air can be admitted to an ejector, as shown in the diagram, to speed up the motor further. The efficiency of the drive is, obviously, dependent on how readily the engine can spare bleed air, but in a hypothetical case for a 15,000 lb thrust turbo-jet the efficiency reaches 80 per cent just below the balancing speed, and remains above that figure for all higher speeds. This set provides up to 7 h.p. to the 8,000 r.p.m. alternator, or 72 h.p. when running from a ground air compressor, and in the starting mode the air motor develops roughly 60 lb ft torque over the speed range up to 9000 r.p.m. The weight of the complete drive is about 90 lb.

Communications and Navigational Aids

Further development of equipment for the Autoland system was seen on several stands. Standard Telephones and Cables, Ltd., showed a new altimeter, the STR 40, aimed specifically at low-level operation in Autoland and Autoflare. Being designed for an operating range of 0ft-500ft, the instrument has simpler circuitry and smaller power requirements than the 0ft-5000ft version, facilitating duplication. All circuits are transistorised except in the transmitter.



Functional elements of constant speed drive and starter



The constant speed drive complete : the drives from the engine and to the alternator are concentric, and opposite them at the far end is the air motor/pump

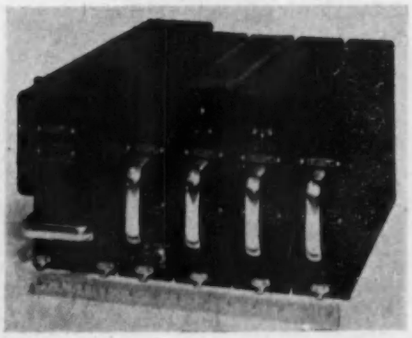
Minimum height reading is quoted as 2ft above the runway, and zero error as not greater than 1ft at touchdown. The transmitter is a microwave oscillator circuit comprising a waveguide cavity which incorporates a velocity modulated oscillator valve. The resonant frequency of the cavity is swept by means of a double-vane butterfly rotated between two capacitive stators. Frequency sweep of the oscillator is adjusted to be exactly 100 Mc/s by varying the insertion of the upper stator. The butterfly vanes are mounted on the shaft of a four-pole synchronous motor which is driven from a 300 c/s oscillator and amplifier.

The receiver mixer is a hybrid ring of microstrip construction. One input arm of the hybrid ring is coupled to the receiver aerial and the other is weakly coupled to the transmitter. The resultant beat between the transmitter signal and the received signal is detected in balanced mixer crystals connected to the two output arms of the hybrid ring. This output signal is fed to the input of the transistorised 80dB amplifier, having a characteristic which rises with frequency up to 150 kc/s, and has a low frequency cut-off below 500 c/s. The amplifier output is fed to the counter unit which incorporates a multi-vibrator triggered one way for every ½ c/s of input frequency. A conventional cycle rate counter provides a d.c. output proportional to height, suitable for driving indicators or an auto-pilot.

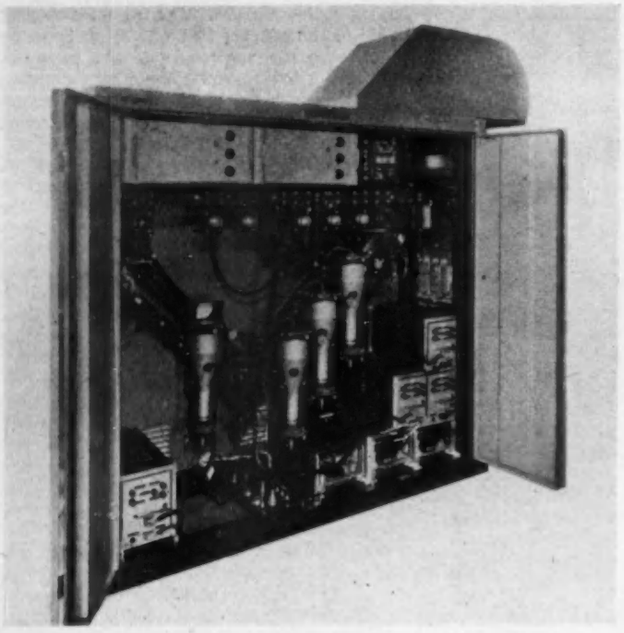
Further applications of transistors to airborne equipment were seen this year in evidence of increasing confidence in the reliability of those devices. Marconi's Wireless Telegraph Company, Ltd., introduced its "Sixty" series of v.h.f. communication and navigational aid equipment in which all items except the power output stages of the transmitter are transistorised The equipment comprises the v.h.f. communications transmitter and receiver units, navigation unit providing instrumentation outputs for V.O.R. and I.L.S. localiser, marker receiver, glide slope receiver, and A.D.F. receiver (100-1799·5kc/s). A new twin-needle radio magnetic indicator introduced for use with the A.D.F. unit incorporates transistorised servo amplifiers in the instrument case, no space being required in the radio rack.

A practical advantage of the transistor in equipments such as the above is that the problem of heat dissipation does not arise. It therefore becomes possible under certain conditions to seal units of a transistorised equipment from the normal environment and to fill them with a dry inert gas, thus enabling them to operate under conditions much nearer to the ideal. In the navigation units, marker receiver and glide slope receiver this is carried out by dividing each into separate sealed modules, consisting of small sections, of rigid construction (to avoid mechanical resonances). These sub-units have a relatively large area and, by arranging them vertically, full advantage can be taken of central cooling systems without danger from dirt and contamination. Should a fault appear in a unit, the separate modules can be completely tested without being unsealed. When the particular module in which the fault lies has been identified, it can be unsealed, repaired and resealed very simply without the use of specialised apparatus.

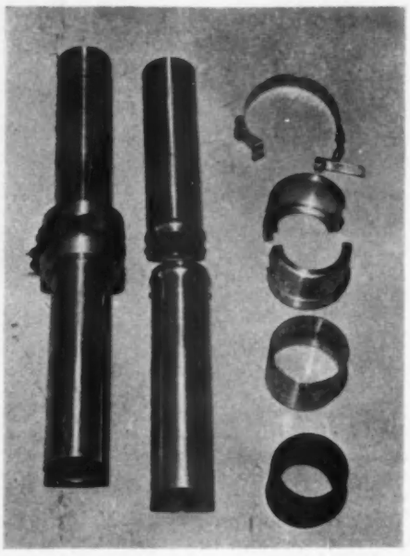
A range of units ("21" series) providing v.h.f. communications, navigation and approach facilities was also shown by Elliott Brothers (London), Ltd., by whom they are manufactured under licence from the Bendix Corporation. Here, again, transistors and printed circuit techniques have been used to reduce weight and space, and a complete installation (illustrated below) for v.h.f. communications, visual omni-range (V.O.R.) and I.L.S. systems weighs about 50 lb and occupies less than a cubic foot of space. Plug-in transistors are used throughout so



Lightweight v.h.f. communications and navigation equipment



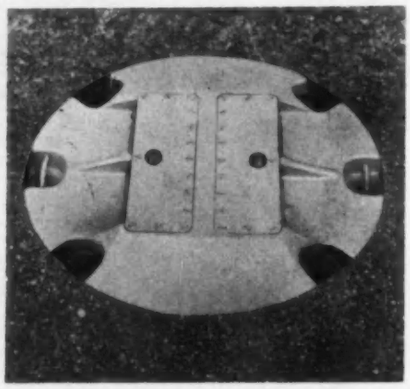
Synthesiser of d.f. triangulation system showing four tubes carrying d.f. information and closed-circuit television cameras for providing a composite display on remote monitors. (Left)



"Flightweight" flexible coupling assembled and dismantled : axial as well as angular movement is acceptable

that replacement does not involve the use of a soldering iron. Instruments available in the "21" series make available to operators of private and commercial aircraft a variety of navigational techniques based on the reception of signals from V.O.R. and A.D.F. beacons. Navigational instruments, also in the "21" series, include a radio magnetic indicator with two pointers giving simultaneous presentation of bearings from V.O.R. and A.D.F. beacons. Examples of facilities available in this way are fixes from two or three cross-bearings, identification of a point at which a turn is to be made on to a new course, and homing to destination with continuous check by cross-bearings from another beacon. We understand that further developments in navigation by means of v.h.f. and m.f. beacons are in hand such as making provision for homing on to any point by creation in an off-course computer of a "phantom" beacon at the desired position, derived from the signals of two known beacons.

Ground direction-finding was represented on the stand of Standard Telephones and Cables, Ltd., by a demonstration of the PVT.2 automatic d.f. triangulation system, in which closed circuit television has been added to the facilities of the existing PRV.1 equipment.



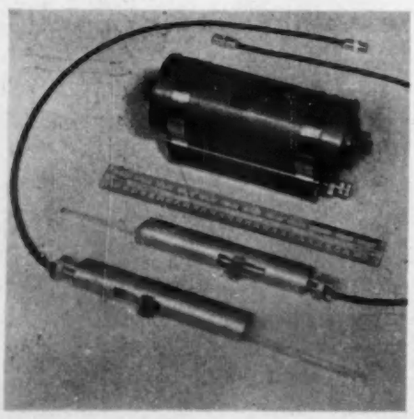
Bi-directional flush runway light for touchdown areas or centre-lines

In association with networks of automatic ground-based wide-aperture direction finding stations, the new triangulation display provides an accurate and convenient aircraft position finder for air traffic control. Its main function is to identify and locate aircraft entering or over-flying controlled air space, using only the signals radiated by the aircraft in the course of ordinary communication with the control centre. Each d.f. station—up to twelve may be used—transmits its bearings automatically over a telephone line or radio link to a control centre, where they are displayed on one of a number of small cathode-ray tubes in a "triangulation picture synthesiser." In this device the bearing indications are combined optically with elements of an illuminated map to form a miniature triangulation display which is viewed by means of a closed-circuit television system. We illustrate the synthesiser unit with its four tubes giving d.f. displays and the built-in television cameras. The television display can be reproduced on any number of separate monitors, or by back-projection on large screens : and can be transmitted to a distant point by radio link if necessary.

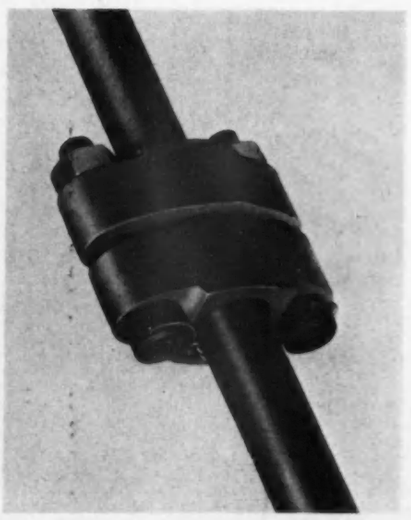
There are facilities for plotting aircraft positions, identities and tracks so that they appear on the monitor displays, and for "storing" aircraft positions on the display by means of electronically-generated markers under the control of an operator. The triangulation system also provides a convenient means of aircraft identification on primary radar p.p.i. displays ; either by direct incorporation of the radar tube in the "picture synthesiser" or by separate radar/television scan-conversion, followed by video combination on a common display monitor.

As exhibited at Farnborough, the equipment was fed with "artificial" signals from a simulator or "live" signals from two direction finders tuned to one of the civil air traffic control frequencies.

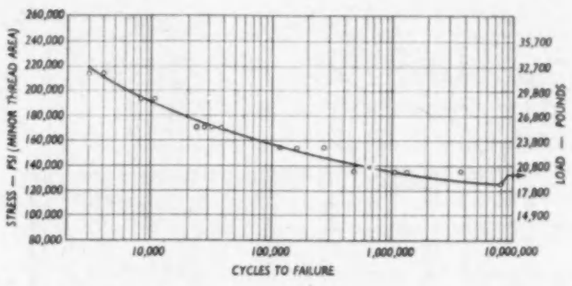
An electron beam parametric amplifier tube unit has been developed for use in the Marconi range of 50cm radars. The tube and solenoid, which we illustrate, are manufactured by the English Electric Valve Company, Ltd. In this device the electron beam passes between the plates of a capacitor to which is applied a pump frequency accurately maintained at twice the signal frequency, being crystal-locked to the radar. In these conditions the effective noise input power is halved because the idler and signal channels, which are symmetrically spaced



Parametric amplifier tube and solenoid, with associated transformers and coaxial lines, for 50cm radars



High pressure pipe coupling with minimum requirements of space for accommodation and spanner clearance



Fatigue strength of bolt of 260,000 lb per square inch nominal stress

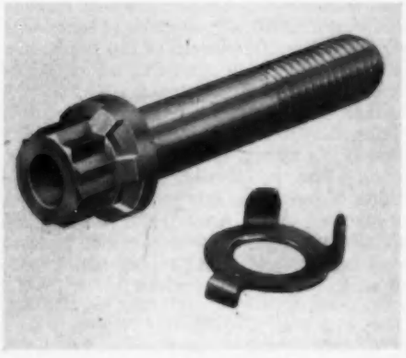
Tension—tension test
⅜in—20 t.p.i. bolt
Low load—10 per cent maximum load
Testing speed—1200 c.p.m.

on either side of half the pump frequency, now coincide. This results in a considerable improvement in the signal to noise ratio of the amplifier output. Other inherent characteristics have enabled a fully coherent moving target indicator system to be used which is said to be the only one of its kind in the world. The tube, it is stated, promises to give a range improvement of up to 25 per cent on 50cm radars, equivalent to more than doubling the output power.

Among visual landing aids, The General Electric Company, Ltd., exhibited a model of its visual glide path indicator, making use of four standard 200W prefocus lamps as a light source. Overall height of the unit is only 10½in and the glass-fibre construction presents little obstruction to an aircraft running off the runway into the unit. The G.E.C. bi-directional flush runway light illustrated is designed for installation in the touchdown area defined by the bars of glide path indicators, or for runway centre-line lighting. It protrudes only ⅝in above ground level. A unidirectional light of this pattern is also made. The company also demonstrated a motor-operated flasher unit for taxiway lights which can be plugged in between the secondary of the isolating transformer and the light to be flashed. Very low power requirements make modifications to the supply or cabling unnecessary.

The flexible couplings for pipes made by Aero Controls, Ltd., have now been supplemented by the "Flightweight" coupling which is, as the name indicates, extremely light, an 8in coupling weighing only 2 lb, and allows 2 deg. of angular movement with axial movement between 0·35in for small and 1·0in for 8½in pipes or 4 deg. deflection with no axial movement. With these departures from alignment, the couplings are leakproof for —11 lb to 500 lb per square inch steady or —5 lb to +250 lb pr square inch fluctuating pressures, when filled with fuel or hydraulic fluid, in the smaller sizes. The construction of the coupling can be perceived in our illustration; the pipes are headed near the ends, and a rubber cylinder with heads at its ends is fitted over them. This rubber cylinder is supported against the pressure by sliding a cylindrical sleeve over it, and to prevent the pipes pulling out of the coupling a flanged housing in two halves is fitted and clamped. For applications involving pressures up to 5 lb per square inch only, such as vent systems, the sleeve may be made in two halves like the housing, and it is then possible to assemble the coupling in very restricted spaces.

Another coupling system suitable for use in confined spaces, but conceived particularly for high pressure systems, was exhibited by M.L. Aviation Company, Ltd., as a result of the firm's finding that no existing system of couplings was leakproof for air at high pressures. The basis of the M.L. system is the use of spherical nipples seating in conical faces, so that a very high-pressure is generated on the in theory, line contact. The first of the two families of connectors offered uses existing A.G.S. hardware, but with a new nipple having part spherical outer surface; the nipple has a split skirt which pushes into the pipe and prevents the nipple falling out and picking up foreign matter. The second family both avoids the need for rather large spanner clearances with A.G.S. unions, and also obviates any risk of swarf from screw threads getting into the joints. This is achieved by clamping the pipes between flanged yokes, the yokes being secured by Allen screws; as there are only two bolts on each coupling, the flanged fittings do not force the pipes away from walls or other flat faces. One of the most interesting fittings in this range is the 360 deg. elbow which takes the place of the ordinary banjo and, unlike the banjo, has no tendency to turn as it is tightened; when the final position of the elbow obscures one of the bolts, it is tightened in a different altitude and then turned to the desired position when the other bolt is loosened. These couplings have been tested to the S.B.A.C. Schedule of Performance Requirements for High-Pressure Pipe and Pipe Coupling Assemblies for a working pressure of 4000 lb per square inch. Tests by British Messier, Ltd., on the ⅜in size demonstrated satisfactory sealing for pressures up to 6000 lb per square inch in the temperature range —60 deg. to 110 deg. Cent. and a fatigue life in excess of 10^6 impulses 0–5000 lb per square inch. For the couplings using two socket screws, it was found that a seal adequate for 12,000 lb per square inch was attainable with a standard Allen key.



Twelve-point headed bolt with provision for locking by means of a tab washer

What was described as "the strongest bolt in the world" was to be seen on the stand of the Unbrako Socket Screw Company, Ltd.; it was not in fact a socket screw but a 12-point bolt made by the Standard Pressed Steel Company, Jenkintown, Pennsylvania—to avoid hydrogen embrittlement, the cadmium plating is applied by vacuum deposition, and this process is not practised by Unbrako. A feature of the design to which particular attention is drawn is the forming of the male threads by rolling; the rolling was performed after heat-treatment in order to leave a fatigue-resistant stress distribution, and it is believed that threads have not before been rolled in such a hard material. To realise the minimum strength of 260,000 lb per square inch tensile offered by these bolts radial symmetry of loading is initial; the squareness of the nut is controlled within fifteen minutes, and the spot facing of the job must be correspondingly accurate. We reproduce the results of a series of fatigue tests in tension on such a bolt; the material is a 5 per cent chromium steel. Equally complete though less attractive results have been established for larger and smaller bolts.

Another Unbrako exhibit concerned with bolts with male heads was a locking device for 12-point heads, which normally have a round base; it consists of a tab washer which can be deformed to engage in one of six recesses machined into the round base.

Foundation for Roll Grinding Machines

By P. H. ALLAWAY*

A RECENTLY completed anti-vibration foundation for one of the largest roll grinding machines in the country presented some unusual features which are thought to be of general interest both in design and in the methods of construction adopted. The machine was manufactured by Waldrich of Siegen, Western Germany, and is installed in the Rogerstone works of Northern Aluminium Company, Ltd.

The need for roll grinding machines which must produce the highest quality work to be installed on an isolated foundation is now widely accepted. It is easily appreciated that a machine which must grind to an accuracy of perhaps 1½ to 2 micro inches, cannot be expected to operate with the necessary precision if its foundation is subjected to vibrations or shocks. These disturbances may arise from many possible causes but particularly in the case of large roll grinding machines, the major source is likely to be the mill itself. As large rolls may weigh up to about 100 tons, the grinding machine is placed as near as possible to the mill in order to reduce handling problems; it is thus, however, subject to a maximum foundation disturbance. Other sources of vibration and shock which have caused trouble with roll grinding machines are gantry cranes, forging presses and hammers, traffic, both road and rail, and roll turning lathes.

Before considering the particular foundation at Rogerstone in detail, it is desirable to examine the various factors which together determine the efficiency of an isolated foundation for a roll grinding machine.

Stiffness

The importance of adequate foundation stiffness is twofold. (*a*) As in the case of most comparatively long, thin machines, the beds of all except the smallest of roll grinding

* Director, Absorbit, Ltd., London, S.W.1

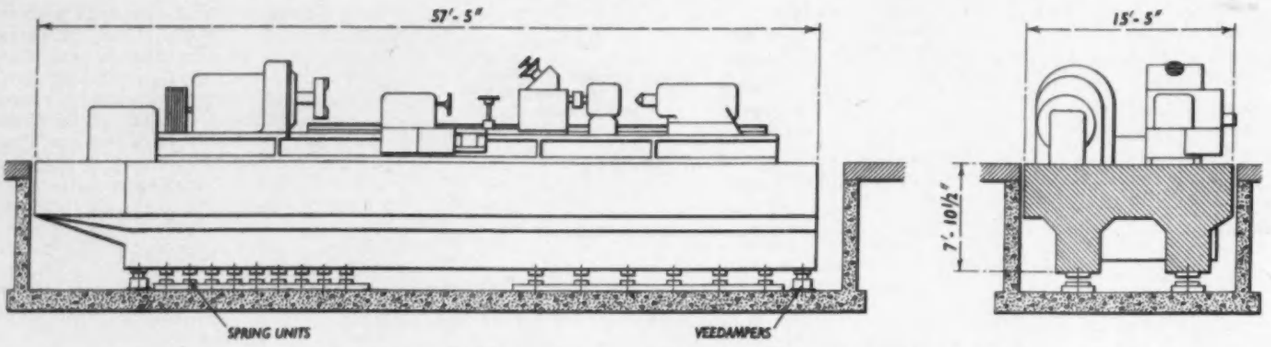


Fig. 1—Arrangement of sprung concrete foundation for a roll grinding machine

machines do not have sufficient stiffness in themselves to prevent harmful deflections due to the moving load of the grinding carriage or roll. This stiffness must be supplied by the foundation. (*b*) Because a roll grinding machine produces no substantial out-of-balance forces or moments, it must not be thought of as a static installation. The dynamic characteristics of the foundation block must be determined and the greatest care taken to avoid any possibility of resonance between a major natural frequency of the block and any machine frequencies, such as motor and shaft speeds or gear tooth frequency and so on. Failure to observe this precaution has led to what can only be called foundation failures, as interaction between the machine and its foundation has prevented the production of a perfect finish on the roll. The result of this foundation defect is often seen as a light, regular shading on the surface of the rolls.

Weight

An adequate distributed weight for the foundation block is necessary to keep the tilting of the machine to an acceptable level. The tilting occurs due to the action of the travelling weight of the grinding carriage or roll on the spring system. Certain discrete levels of tilting have been proved to have no harmful effect whatever, provided, of course, that the foundation and machine move as one unit.

Spring System

It was at one time thought to be adequate to use comparatively stiff springing for the protection of roll grinding machines. This has been proved to be wrong. It is essential to use soft springing if complete isolation of disturbing vibration and shock is to be guaranteed. The ground movements which have to be isolated from the machine are frequently caused (as listed above) by shocks which excite the ground into vibration at a particular natural frequency. On many industrial sites this frequency will be from 10 to 15 c/s and the use of spring systems with vertical natural frequencies of this same order risks a condition of resonance which would amplify, not isolate, ground vibration. A further danger of the use of these stiffer springs is resonance between the spring natural frequency and some machine frequency such as mentioned above. A condition of resonance can prevent the machine producing a "mirror finish." The soft spring system can easily be provided by using steel helical springs, but rubber springs may in some cases be convenient.

Damping

Modern damping techniques and materials make possible an improvement in the quality of shock isolation without noticeable deterioration in the quality of vibration isolation. In the past this has not been possible and there was a consequent limitation on the efficiency of any isolated foundation.

The general arrangement of the foundation at Rogerstone is shown in Fig. 1. It will be seen that to obtain the necessary stiffness a concrete thickness of nearly 8ft was used. The cross section shows that an arch or bridge form was used. This gave a saving in concrete and improved the accessibility of the spring units and dampers. This foundation shape, however, is used only for the largest roll grinding machines. Normally a more conventional rectangular cross section is used. In this case the arch form gave the civil engineers of Northern Aluminium Company, Ltd., an opportunity to adopt a somewhat unusual method of installing the foundation. The mill in which the machine was to work contained a 125-ton gantry crane, and it was decided to precast the two legs of the arch on the floor adjacent to the foundation. Fig. 2 shows these legs, weighing about 45 tons each, in position in the pit and the connecting reinforcing bars are seen protruding from the upper surfaces. Part of the lifting tackle can also be seen as well as one of the dampers, as yet unconnected. The spring units are already in position but rigid blocks are supporting the weight. After the top of the foundation block had been cast (Fig. 3) and the machine erected, a system of coupled hydraulic jacks was used to transfer the weight from the blocks to the spring units. It is believed that this method obtained substantial saving in costs and could well be adopted again whenever suitable lifting gear is available.

The design of the spring and damper system and the outline design of the foundation block was by Absorbit, Ltd., and this company wishes to thank Northern Aluminium Company, Ltd., for permission to publish this article. The designers and contractors for the high quality reinforced concrete work were G. Percy Trentham, Ltd., and the U.K. agents for Waldrich-Siegen are Alfred Herbert, Ltd. Acknowledgment is made to these companies for assistance in preparing this article.

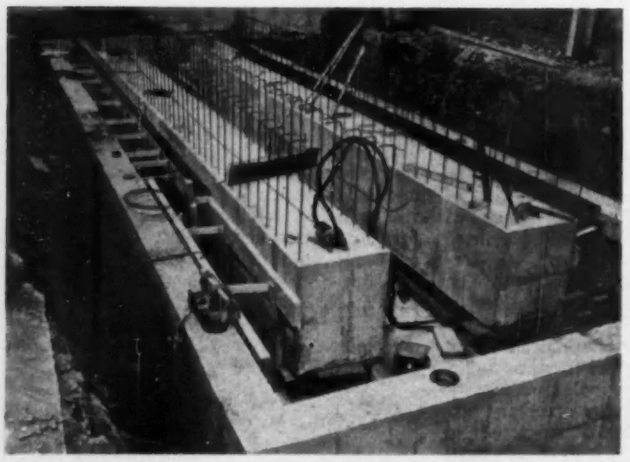


Fig. 2—Legs of the concrete arch were precast alongside the pit and then lowered into it as shown here. Their weights are supported by rigid blocks

Fig. 3—The top of the foundation block was cast on to the legs and the machine erected. Afterwards, jacks were used to transfer the load to the springs

Engineers and Industrial Accidents

By A. A. BECKINGSALE, M.I.E.E.

The author of this article points out that engineers have a much greater part to play in industrial accident prevention than they seem to accept at present because of their interest, influence, and importance in all aspects of industry. He shows also how very high is the cost to industry and the country of industrial accidents.

ENGINEERS are nearly always involved in the design and layout of buildings and plant, of transportation and services ; they are involved in site works of any size, and finally the engineer maintains, and in many cases is responsible for, the operation of the plants and processes which may range from mining to moon rockets, from roads to reactors, or from ships to shops. Most engineers are intensely interested and absorbed in the technical aspects of their work which is mainly concerned with the fashioning and control of materials such as concrete, metal, wood, chemicals. The problems challenge them and the completed work satisfies them. But due perhaps to this keen technical interest, there is a tendency to forget the fact that all these projects have to be constructed and worked by ordinary men and women, who, in the course of operation and maintenance, are required to move about the plant, to lift and to carry things, to read instruments and to operate controls so that the various devices may serve the community.

Great stress is placed on the efficiency of a process because of its financial advantages ; and on the reliability of the plant because of the financial loss resulting from breakdown. Everything possible is done by the engineer during design, maintenance and operation to achieve high efficiencies and to minimise breakdown of, or damage to, plant and equipment which, should it occur, is subject to strict inquiry at high management level. Almost certainly some action will be taken or alterations to design put in hand to prevent a repetition. In general, there seems no difficulty in finding the money for these purposes. In contrast, generally speaking, the same attention is not paid to minimising breakdown (accidents) of men and women constructing and working the plants. This could have just as much effect—if not more—on the economy of the nation or of the firm concerned. Plant can be replaced whereas dead workmen and severed limbs are lost for ever. It is questionable whether there has been real efficiency if, in the achievement of a high engineering and financial efficiency figure, the accident rate is also high.

It is an accepted engineering practice to design for conditions which are assumed to be the worst the equipment is likely to experience in service. In contrast, the facilities given to men to do their work about the plant assumes not the worst but the best conditions. It is assumed that they are always, all the time, in good physical trim, fully alert, and can see equally well in glare or gloom. Those who have the slightest knowledge of men and women would agree that to expect this level to be maintained continuously is optimistic in the extreme. It is unnatural and will not be realised. Further, to make sure that materials will not fail, a generous factor of safety is imposed on top of the worst conditions, but no such latitude is given to what can be termed " the human engineering side," although there is considerably less knowledge about men and their reactions than about materials and their characteristics. No criticism of the design criteria for the material engineering is here offered. But the plea is raised that similar standards should be attempted for human engineering.

About 2200 men and women are killed in industry each year[1] and another 700 so maimed as to be as good as dead so far as industry is concerned ; 870,300 others are injured in varying degrees to the extent that on an average they are prevented from working for twenty-five days in each year. This terrible toll of human life and limb, with its accompanying grief, pain and suffering, is ample reason for engineers to give industrial accident prevention deep consideration and action, rather than the lip service which is all too prevalent. There is also a financial aspect to the matter, and those who are not readily convinced on the humanitarian side can sometimes be wholly converted by an examination of pounds, shillings and pence. The average cost to the national economy of every one of the 783,200 industrial accidents[2] is over £200 each, or at least £157,000,000 annually!

Engineers can play their part in preventing accidents and reducing the drain on the country's resources by designing and constructing their buildings and working the plant so that it is easy for men and women to work without an accident, and difficult for them to have one. This is a matter of urgency, as in some plants now being constructed, not to mention old ones, they are not so designed and worked. To enter into details as to what engineers can do to prevent industrial accidents is not appropriate to this article, as most engineers, if they care to study the subject or to seek advice, will obtain the answers readily enough. But certain general improvements that can be made are mentioned.

Persons are required to move about during their work, making use of gangways and platforms. These are often at different levels from their surroundings and their edges should be efficiently fenced to prevent persons falling from them. To be efficient, fencing should always consist of at least a handrail, mid-rail and toe-board, the latter being essential in order to arrest any initial slip. Together with the mid-rail it will prevent a person who has already fallen from rolling over the edge. Toe-boards also prevent articles falling over the edge on to persons below, which is a fairly common cause of injury.

The accepted way of moving from one floor level to another is by means of stairs. Stairways of a standard rise and tread are met with in our homes, in theatres, railway stations and public buildings generally. This standard, however, is not followed in many factories and industrial buildings. Instead, a series of fixed steps with handrails having various inclinations and varying risers and treads, with the treads often overlapping, are substituted presumably as a matter of expediency. Thus, for a period, every day during working hours, persons have to adjust themselves to abnormal, differing and unconventional conditions which, if accidents are to be prevented, they should not be called upon to do, and which, in any case, lowers their efficiency. Lack of space is often put forward as an excuse for the erection of unconventional stairs. In a few cases more space may be needed and should be provided ; in others, the exercise of proper engineering skill and ingenuity can provide conventional stairways in the original space. Treads of stairs seem automatically to be either of iron or concrete. The possibility that, in some circumstances, these materials may not be suitable and may cause accidents should be considered.

The monetary cost, as well as the injury cost, of accidents, is a serious matter which should be remembered during design and planning. For instance, to spend money on installing non-slip treads on stairs is an economy ; not to do so is an extravagance, for the total monetary cost of one accident would pay for non-slip treads on many stairs. Other instances could be quoted, but there is, I think, considerable prejudice to be overcome before this idea is accepted, even where qualified engineers are concerned.

Fixed conventional access to all places where operators have to work should be provided. The need to stand on pipework in order to operate valves, or the need to climb on equipment and plant to read instruments is inefficient and costly both in injuries and in money, as is proved by the accidents when these methods are used. The enclosure of dangerous parts of machinery within, and as part of the design of the machine, should be considered in the first instance, leaving a minimum of guards to be added after erection. Standards of lighting should be generous. If a trap can be illuminated it can be seen, and avoided.

Constricted working space and lack of headroom creates considerable problems in the handling of equipment, and nearly always means that lifting, both human and mechanical, is inefficient. This inefficiency will reveal itself in accidents to the workman doing the job and in damage to the equipment, and will be costly in both injury and money. It may require considerable skill to lay out the plant so that there is proper room for maintenance, and adequate lifting facilities, without adding unduly to the cost. Such skill is available and should be used, for if sufficient space is not provided it must be realised that its omission will have to be paid for some time during the life of the plant, either in money or injuries, probably in both.

The planning and carrying out of operations and maintenance should receive professional attention. Engineers should make sure that when issuing instructions sufficient facilities and men are available on the job, and that local supervision is competent to do the work safely. To issue instructions without doing this, hoping that somehow they will be carried out, but discreetly not inquiring how, is not only shirking professional duties but inviting injury to men and damage to the plant.

The professional Institutions, while pursuing the advancement of their sciences, should see to it that the brilliance of the technical designs and achievements of their members is not diminished by casual treatment of the means provided to operate, maintain and work them. Admittedly, there is much more glamour and excitement in designing a piece of machinery than a staircase, but both, as matters of engineering, should receive the same amount of consideration. There are many times more accidents caused by falls than by machinery.

It may be said that the customer calls the tune, and that he is interested in the cheapest equipment that will do the work he wants. When this is the case, the tendency appears to be to cut down various ways associated with maintenance and operation facilities, and substitute those of inferior quality. This is a short-sighted policy in the extreme, since the customer's real interest is in the safer equipment, which will be cheaper in the long run. He should be told that, more often than not, for hundreds of pounds saved on capital expenditure, thousands are spent on more complicated operating techniques, maintenance procedures, and on accidents.

Professional engineers should explain the need for safe access and for safe plant to the customer, putting forward their views and arguments on industrial accident prevention on the grounds of humanity, efficiency and ultimate cost, at the same time offering alternative safe designs. Those customers who are advised by consulting engineers or who have professional engineers on their staff, will, it is assumed, have been advised of these matters, and it is difficult to believe that they would reject any advice they had been given.

The fact that the workman, and not the engineer, suffers the accident (at least 95 per cent of all accidents are suffered by manual workers), due perhaps to some omission or momentary aberration on his part, is inclined to bring the blame to focus on him, and, undoubtedly, in certain cases he is the author of his own misfortune; but more usually, the conditions under which he was working and the method of work employed were far from good, and should not have existed or been allowed. The real cause of many an accident can be traced back to a poor design on a drawing-board years before it occurred.

Engineers must have a clear conscience in this matter in that the plant they design, the equipment they put forward for use, and the method of work adopted should be to the highest standards of their profession, and should assist, rather than hinder, the work of men and women. Should an accident occur, engineers should subject themselves and their colleagues to rigorous self examination, to discover whether they have failed in any of these requirements, before looking elsewhere to allocate blame.

Cost of Accidents.—The result of any accident is fortuitous; the simplest of circumstances may result in a fatality, whereas there are occasional miraculous escapes of several men from a catastrophe that might well have killed them. In the same way, the cost of accidents may vary; some appear to cost little more than the loss of output of a single worker for three or four days, plus some administrative work, while another, to take an example within the author's knowledge, killed two men, injured seven, and cost nearly £500,000 in material damage. The application of a cash value to grief, pain, widowhood, loss of parents, loss of sight, is, of course, impossible; and such losses are tragic, irreparable and final. An attempt is made, however, to compensate injured persons for the loss of income they or their dependants sustain because of disablement or death. This is done by the State under the provisions of the National Insurance Industrial (Injuries) Acts and sometimes by the employer by agreement, or on the direction of a Court.

Other costs are those of medical treatment, the damage to plant, loss of output while the injured person is away from work, loss of output from wrecked plant, internal re-arrangement and upset in the factory. It is possible to obtain some of these costs but some have to be estimated.

(*a*) In 1957 there were 16,200,000 man-days and 2,560,000 woman-days of work lost[3] due to industrial accidents.

Assuming the money's worth of the output of a day's work to be at least equal to the wages paid (men £13, women £7) then there was a loss of output for the year of £47,324,000.

(*b*) During the same year injury benefit, disablement benefit and pensions, together with administrative costs, amounted to[4] £41,211,000.

(*c*) The total cost of hospital, medical and the dispensing services in this country for a population of 52,000,000 is in excess of £510 million.[5]

The working population numbers 24,000,000; therefore, the proportion of cost attributable to them can be estimated to be £236 million. The working population have 7,887,000 spells off work for sickness[6] and 781,000 spells off work for injury per year. Therefore, the proportion of the cost of these services for injury amounts to, say, £23,500,000, giving a total of, say, £112,000,000.

(*d*) In 1957 there were 781,000 spells (men twenty-three days, women thirty-two days) of absence from work due to injury. The average cost of each accident, therefore, amounted to, say, £145. Other costs for each accident have to be estimated, such as:

(*e*) Legal costs and compensation from employers, £20.

(*f*) Disturbance of work sequence, overtime, additional costs, £10.

(*g*) Damage to buildings and equipment, £10.

(*h*) Loss of output due to (*g*), £10.

(*i*) Administrative costs, first aid, travelling, accident investigation, £15, giving a total of £210.

This estimate takes no account of payment of make-up wages to the injured person while he is away, which is the practice of some employers, and would increase this figure from £210 to £231.

The estimated figures have been kept to a low, perhaps only a nominal, value. It is interesting to record that Mr. R. H. Coates, the Controller of the Southern Division of the Central Electricity Generating Board, in his Presidential Address in December, 1958, to the West Sussex Accident Prevention Group, quoting the results of the costing of accidents in his Division, found that the average cost per lost-time accident was £78. This figure did not include any sum under items (*a*), (*b*), (*c*), (*d*) or (*e*) mentioned above. These figures appear to confirm that the estimates offered are on the low side.

Taking the values quoted by Mr. Coates, the average cost of every lost-time accident would rise from £210 to £243 each. Incidentally, the Electricity Supply Industry is one of those industries which makes up an injured employee's wages, so that for it and others like it, the figure would be £264 for each accident. In the editorial columns of THE ENGINEER for November 27, 1959, Mr. G. H. Stuart Price is quoted as saying in his paper, "The Cost of Safety and the Cost of Accidents," read before the London Building and Civil Engineering Contractors Accident Prevention Group, "that for every lost-time accident there are at least fifty where no time is lost, each one averaging £10."

Taking half of both of these figures in order to avoid any charge of over-estimating, the total cost of these accidents where no time is lost, based on the 781,000 lost-time accidents is, say, £100 million.

That figure provides a measure of the seriousness of the problem and of the need for action. It is obvious that the nation has to find this money and when it has done so and paid the bill, what is there to show for it? Nothing! That is except the widows, the maimed, the injured and an irreparable loss of skilled craftsmen. If, however, the accident can be prevented—and a great many can—a large proportion of this money is saved and, more important, injury is avoided.

Engineers should consider these facts when they are planning, designing, constructing and operating civil, electrical and mechanical plant and equipment, so that accident-producing situations are reduced to the absolute minimum and we are not penny wise and pound foolish.

REFERENCES

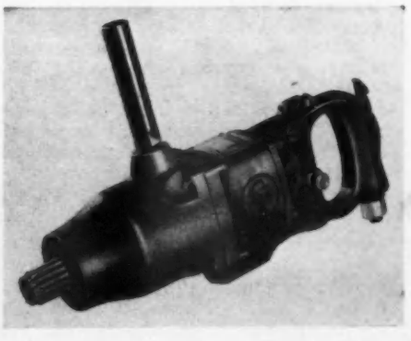
[1] Report of Ministry of Pensions, 1958, Table 47.
[2, 3] Report of Ministry of Pensions, 1958, Table 42.
[4] Report of Ministry of Pensions, 1958, Appendix III.
[5] Report of Ministry of Health, 1958, Table 3.
[6] Report of Ministry of Pensions, 1958, Table 32.

Torque Controlled Impact Wrench

A TORQUE-CONTROLLED, reversible, impact wrench, introduced by the Consolidated Pneumatic Tool Company, Ltd., of 232, Dawes Road, London, S.W.6, is illustrated below. This tool operates as a conventional wrench until the preset torque value is reached, when the torque control device cuts off the air supply to the motor.

The required loading is obtained by the setting of a torque adjustment screw on the handle of the wrench and, if required, a button on either side of the handle can be pressed to lock-out the control and allow the wrench to develop its full capacity.

The wrench is available in two forms, one model being equipped for spline drive, whilst the other has a 1in conventional square drive.



Torque controlled impact wrench with spline drive, this tool has a torque adjustment between 300 and 690ft lb

In the spline drive tool the retainer is integral with the shank and is automatic in operation, and a quick release button in the shank is used to free the socket for removal.

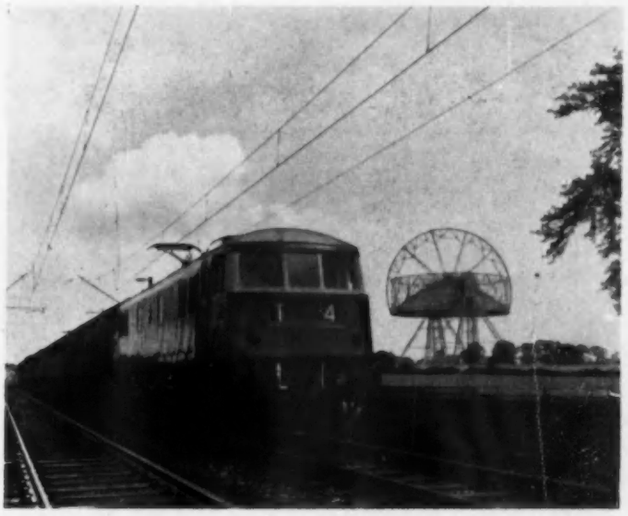
The weight of each model of these tools is 23 lb, and they have an overall length of 16¼in. They are suitable for a maximum bolt size, when using the lock-out, of 1¼in, the minimum torque being 300ft per pound and the maximum 600ft per pound.

[Reply Card No. E4602]

First British 25kV Main Line Electrification

No. 1

Electric working of public train services on the Manchester-Crewe line of the London Midland Region, British Railways, was formally inaugurated by the Minister of Transport on September 12. This is the first stage of the high-voltage a.c. programme covering the main lines from both Manchester and Liverpool to London, Euston. General modernisation of technical services and public facilities throughout the route includes the rebuilding of London Road Station, Manchester, and its re-opening as Manchester Piccadilly.



THE Manchester to Crewe line of the London Midland Region covers 31 route-miles and totals 117 miles of track. Although the British Railways high-voltage a.c. scheme provides for operation at 6·25kV instead of 25kV where it is impracticable to enlarge restricted clearances, the whole of the present work has been carried out at 25kV. In order to do so, eighty-two out of ninety-two bridges had to be heightened, and three tunnels at Stockport were opened out, requiring the construction of two new bridges to carry roads over the railway cutting. One of these bridges is 170ft wide between parapets in order to accommodate a traffic roundabout. By these measures the required clearance of 11in between the contact wire, or equipment at high voltage, and earthed structures has been attained everywhere.

Electrical supplies are taken from the grid at Heaton Norris (near Stockport), and at Crewe. These two points are approximately 27 miles apart. At each place connection is made with one phase of the grid through a 132kV/25kV transformer. Less than 7 miles of feeder cable has had to be provided. There are seven track sectioning cabins on the route, including the loop via Styal, with switchgear for isolating sections of the catenary ; and between consecutive cabins there are four or five isolating facilities in the form of motor-operated switchgear mounted on the overhead structures. All switchgear is under remote supervisory control from a control room at Crewe (Fig. 1) by means of a voice-frequency system supplied by the Automatic Telephone and Electric Company, Ltd.

The overhead system, for which the contractor was the British Insulated Callender's Cables Group, includes compound, simple, and stitched catenaries, for in this first stage of the major scheme it was desired to gain experience of different forms of construction. We were informed during an inspection of the scheme last week that the compound catenary is preferred for speeds of 90 m.p.h. and more such as will be run on these lines, and for facility in erection. This latter advantage is concerned particularly with ease and permanence of registration of the contact wire over the tracks at the supporting structures, and with maintenance of gradient where the wire passes under bridges and other structures.

The overhead system is divided into weight-tensioned lengths of 1¼ miles. Cross section of the contact wire is 0·166 square inch. Generally the ends of these tension lengths are convenient points for the installation of the booster transformers which are provided in order to confine return traction current to the running rails. These are 1 : 1 transformers with their primaries in series with the contact wire and their secondaries connected to adjacent sections of the running rails. Where these connections are made they are separated by a 40ft length of rail, which is isolated from adjacent rails by insulated joints at both ends. The effect of the transformers is to confine the return current to the running rails so that it flows through them back to neutral at the supply point rather than leaking to earth and possibly interfering with tele-communications circuits. Booster transformers at Stockport are seen in Fig. 2.

Overhead structures are earthed by bonding to the running rails where rails are not carrying track circuit currents for signalling. Where double-rail track circuits are in use, the structures are interconnected by a separate earthing cable. A section of simple catenary with this cable suspended from the lineside structures is seen in our heading illustration.

Experiments are being made with various methods of insulation and good results have been obtained with "Fibreglass." This material has been used for the cantilever arms themselves at some structures. The signalling contractor was the Westinghouse Brake and Signal Company, Ltd. Track circuits between Manchester and Crewe are either single-rail d.c., fed from rectifiers, or double-rail 75c/s, a.c., with static conversion equipment providing the special frequency from the standard 50c/s input at the feed end, and rectifiers operating d.c. relays at the relay end. The latter system is used for track circuits over 500 yards in length. At Crewe and Manchester, however, the concentration of tracks would have made the provision of individual converters for every circuit uneconomic, and at these places an 83⅓ c/s signalling supply is generated centrally by rotary converters.

Signalling is by three-aspect or four-aspect colour-lights. By means of "Westronic" electronic remote control equipment it has been possible so to extend the area controlled from individual boxes that three new signalboxes have replaced twenty-nine formerly in service. Mechanical interlockings previously operated by local boxes have been converted to relay interlockings, each connected to its controlling signalbox by a single-pair cable. Interrogating pulses continuously scan the condition of all relays, and return indications are sent back over the same channel. In these installations the system operates to a scanning cycle of 150 steps a second. Transmission of controls and indications is on carrier frequencies in the range 25 to 45 kc/s, two carriers differing by 5 kc/s being used to differentiate between

Fig. 1—Power supplies and distribution control room at Crewe

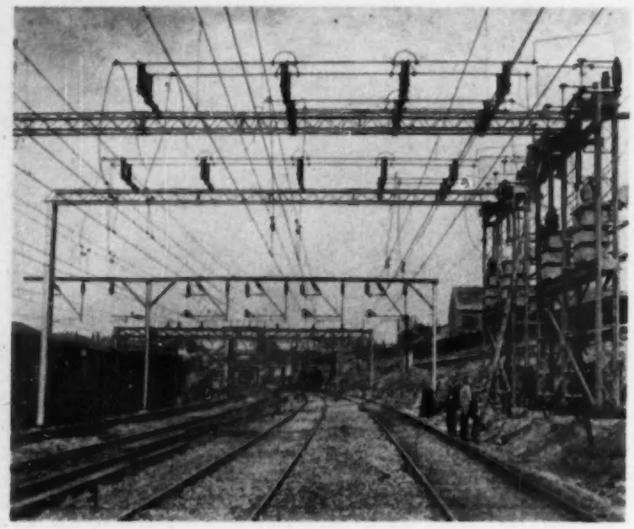


Fig. 2—Booster transformers mounted in overhead line structures (right) at Stockport

Fig. 3—New signalbox at Manchester Piccadilly and electrified connection to Oxford Road station in left background

the " up " and " down " conditions of relay contacts, or the corresponding positions of the control switches on the signalbox panels.

The equipment described is fully transistorised and is designed for rapid interchangeability of all parts. Electronic circuits are on printed-circuit boards which slide in and out of their chassis, enabling a complete circuit to be replaced without unsoldering or renewing connections (Fig. 5). The register relay unit, which stores the information relating to the condition of all controlled equipment, is similarly replaceable *en bloc*, or a complete cubicle containing the above items can be substituted for another if required. Spare equipment is carried to enable such substitutions to be executed without delay, and test rigs have been developed so that signal linemen can test the spares before use. The manufacturer is collaborating with the railway by running one-week courses at the works to familiarise linemen with the equipment.

The new signalbox at Manchester Piccadilly is seen in Fig. 3. This controls interlockings at Slade Lane Junction, Mauldeth Road and East Didsbury, by means of the electronic apparatus described above. On the Slade Lane circuit fifty controls and indications are provided, enabling changes in the signalling here to be repeated back in one-third of a second. Manchester Piccadilly is the largest of the three new boxes, controlling 500 signalled routes in an area extending to East Didsbury on the Styal loop line, Heaton Chapel on the Stockport line, and Ashburys on the Sheffield line, including the connections serving Longsight carriage and motive power depots. Longsight is the limit of direct working from the box, the remaining interlockings to Heaton Norris Junction (8 route-miles) being electronically controlled. An electronic system for Longsight would not have been economic, but the cost of the direct-wire circuits has been kept down by using small-gauge wire and miniature relays in conjunction with 50V instead of 24V for relay operation.

The box is operated on the Westinghouse O.C.S. (one control switch per route) principle. Train descriptions are displayed in illuminated windows on the track diagram, individual descriptions appearing in positions corresponding to those of the signals the trains concerned are approaching at any moment. These indications, given in a four-digit code, are exhibited by an optical method of illuminating only the required characters. The train describer system was supplied by Standard Telephones and Cables, Ltd.

A development in this signalbox designed to improve flexibility in handling traffic and keep it on the move enables trains to be signalled forward to a junction signal which is " on," although the overlap on the route of first choice may not be clear, providing that a second route from the signal offers the necessary clear overlap. If the first route becomes available as the train approaches the signal, it may still be taken, the alternative being cancelled by pressing a button. Otherwise it may be possible to route the train past the obstruction by a parallel route.

In installing the signalling it was necessary to site equipment cases containing signal relays as close as possible to the signals themselves, for it has been found that induced voltages from the traction supply can in some circumstances cause signal lamps to glow. For similar reasons line circuits are restricted to a length of $1\frac{3}{4}$ miles, after which a repeater relay is inserted. At one time the question of providing warnings of approaching trains at Jodrell Bank radio

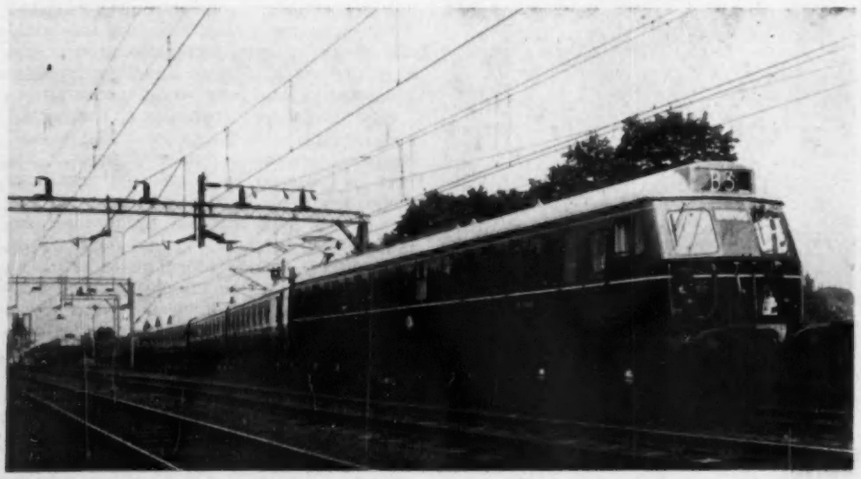


Fig. 4—Multiple-unit rolling stock. The left-hand and adjacent catenaries are respectively compound and stitched

Fig. 5.—Electronic control cubicle for signalling, showing printed circuit panels, carrier transmitter and receiver (above) and relay register (below)

telescope was studied—its proximity to the route is emphasised in our heading picture—but no interference has been reported so far. The usual stand-by power arrangements for signalling are supplemented by provision for taking current from the traction system.

Some of the multiple-unit stock for the new services is seen in Fig. 4. The set illustrated follows the practice already seen in the multiple-unit trains for the Fenchurch Street–Southend service of dividing the traction equipment between a battery driving trailer and an adjacent motor coach. The equipment was supplied by the Traction Division of Associated Electrical Industries, Ltd., and includes germanium rectifiers for feeding the four 194 h.p. motors in each motor coach. Local services operated by these sets can now run through Piccadilly station at Manchester to Oxford Road, which has become the interchange point with the 1500V d.c. electrification to Altrincham. Oxford Road is the first station in this country to have 25kV a.c. and 1500V d.c. catenaries side by side. Plans have been prepared for converting the Altrincham line to a.c. to allow through running, and it is expected that the section through Trafford Park tunnel in Manchester will have to be operated at 6·25kV. Goods between Manchester and Crewe is not being worked electrically at present, pending provision of clearances in the tunnels which enable trains from the Manchester, Liverpool and Chester directions to by-pass Crewe station on their way to and from the yards south of it.

Demonstration Journey

In the course of the press inspection of the line on September 8, the ability of the type A locomotives to reach their nominal maximum of 100 m.p.h. was demonstrated. B_0-B_0 locomotive No. 3025, one of those supplied by The English Electric Company, Ltd., covered some five miles with a five-coach train at a minimum of 97 m.p.h. and reached 102·3 m.p.h. while still accelerating between Goostrey and Chelford. This performance was a further demonstration of the accelerative powers of the locomotive which were evident immediately on starting from Crewe, for the high-speed stretch was preceded by a slowing for bridge reconstruction near Holmes Chapel.

(To be continued)

British Association at Cardiff

The British Association for the Advancement of Science held its annual meeting at Cardiff this year from August 31 to September 7. Our representative attended the meeting and here reports on subjects discussed at Cardiff which seem to him to be of interest to engineers

THE real difficulty about attending a meeting of the British Association for the Advancement of Science is that so often one would like to be in several different places all at the same time! There are now thirteen sections of the Association lettered from A, Mathematics, to N, Sociology, of which G, Engineering, is, of course, of special interest to readers of this journal. Additionally, there is an Assembly of Corresponding Societies which represents those who, without being scientists themselves, are interested in science. Each meeting of the Association, by custom, extends from about midday of Wednesday of one week to about midday of the following Wednesday ; and upon each morning except for the Saturday and the Sunday, each Section holds a separate session ; some, indeed, hold two simultaneously—Section G amongst them. Thus upon consulting his programme any member attending the meeting will find, as likely as not, things going on in two or more Sections simultaneously which he would have been delighted to listen to. He will, in fact, be forced repeatedly to make unwelcome choices, unless he is content to attend only the meetings of his own Section. But as the Association more and more comes to think that its *forte* is to encourage scientists to understand what other scientists are doing and, even more, to put across to the general unscientific but intelligent public what scientists are about, anyone who confines his attendance only to his own Section is not really playing the game! Nor, it should be added, is he really savouring to the full the flavour of a British Association meeting.

In a similar way each Section each afternoon and all day on Saturday and Sunday organises excursions to works, buildings, geographical or geological areas and other places likely to interest their members, while the Association as a whole also organises excursions of more general interest and of a sight-seeing character. Again, therefore, a member may find himself distractedly trying to choose between, for example, a visit to a famous engineering works which he may never again have an opportunity to see or a trip, let us say, to a local mediaeval castle under the guidance of a world authority on such buildings—a unique occasion.

Additionally there are invariably other activities attracting attention. Evening receptions are held; and each Section lays on its own dinner. There is sometimes a dance or a concert or both. There are usually at least two "Evening Discourses" delivered by world famous scientists and intended for scientific but not specialised audiencies. Often special exhibitions are arranged to connect with some theme of the meeting and there is always a show of scientific and industrial films.

The meeting of the Association held at Cardiff this year (the Association is peripatetic and meets in a different place each year) was in one way exceptional. For on Monday, September 5, no sectional meetings were held. Instead the members gathered together in the Sophia Gardens Pavilion to hear a Symposium of papers on "World Food and Population." It lasted, with a break for lunch, from ten in the morning to five in the evening. But some members deserted it, preferring to find their own amusement or instruction or to go on various excursions which were organised during the afternoon.

Each year the meeting is inaugurated at an evening gathering on the first Wednesday, at which the President presents his address. We have already printed extracts from this year's Address by Sir George Thompson in our issue of September 2. Additionally each Section has its own President and each of these presidents presents an address at some time during the meeting. Sir Alfred Pugsley was the President of Section G, Engineering, this year and we printed his address almost in full in last week's issue.

Our present purpose is to survey what went on at this year's meeting ; of course with special reference to the work of engineers. But we shall certainly not confine our attention to the affairs of Section G alone.

World Food and Population

The fact that a Symposium was to be held under the above title at Cardiff seems to have led to the inclusion in the proceedings of a number of Sections of papers having some relevance to that subject ; but not in Section G. In fact the direct interest of the Symposium for engineers turned out to be rather limited.

The general picture of the world situation was well enough painted. World population reached about 1000 million in 1830. It was double that figure about 100 years later and it is estimated to be now about 3000 million. The rate of increase tends to be logarithmic ; and unfortunately it tends to be highest in just those underdeveloped areas of the world where living standards are already low and populations undernourished. It is commonly believed that, as world population is increasing logarithmically and as the rate of increase of food supplies can only be arithmetic, there must soon come a time when a limit to world population will be imposed by food supply. On the longer term that is, indeed, no doubt true. But it was made abundantly clear at the Symposium that on the shorter term plenty of food can be made available for a very long time ahead provided the right actions are taken. For the yield of the land is open to great improvement. In Japan where as much as 100 lb of fertiliser is now applied per acre the average paddy-field produces 35 cwt per acre; whereas in India, where only 1 lb of fertiliser is applied per acre overall, the yield is barely one-quarter as much. A similar picture is revealed by the figures for wheat. That no extraneous factor is involved is indicated by the fact that experimental farms in India have yielded amounts per acre comparable with those common in Japan. Clearly, therefore, there is scope for obtaining a very large increase in food supplies merely by cultivating lands more efficiently through the application of known and proved methods without having to rely on new scientific or agricultural discoveries. Furthermore; crops are at present grown, and animals grazed, on only about one-tenth of the land surface of the earth, whereas, in fact, about one-third of that surface could potentially produce food.

The overall picture is thus far less gloomy than it has often been painted and to make things appear less gloomy still Dr. Norman C. Wright at the Symposium was able to point out that "contrary to widely held belief, available statistics indicate that world food production is currently increasing at a slightly faster rate than world population." But no one should feel too relaxed about it either. As Dr Kay. put it "Whatever the statistical world picture may be, when one comes down to individual countries, and still more to individual districts and population groups, not only most of the technologically underdeveloped countries, but one or two of the technologically better-developed ones are at present grossly under-nourished" ; and for these regions "if the amount of home-grown plus imported food supplies are rising at all they are rising at a rate well below the net rate of population increase." Dr. Kay also pointed out that short of a world authority "with power to direct food supplies on a gift basis from surplus countries to underfed countries" the statistical world figure has little relevance for hungry peoples.

Effectively he seemed to think the only reasonable hope for undernourished countries was that they should pull themselves up by their own bootstraps ; and it is not shortage of available scientific, technical or nutritional knowledge that prevents them from doing so. It is rather " the extreme slowness of implementation of that knowledge, a slowness caused by political, sociological, and psychological obstacles to overcome which effective techniques have yet to be found." In a paper before Section F, Economics, Mr. Reddaway made the same point in a different way. " In agriculture the main need is for a campaign to persuade cultivators to use better methods. These will require more fertilisers . . . . . Some extra working capital will be needed . . . . . but the difficult part is the effective spread of the improved methods, rather than the provision of the capital . . . . . So-called structural reforms—e.g. on land tenure and price guarantees—may be needed as part of the programme."

It would seem that one of the major services well-developed countries could perform for the underdeveloped ones would be to provide the expert knowledge and the teachers to show people in such lands how to produce larger crops, how to make use of fertilisers, how to build dams and develop water power, and how to dig irrigation channels and the like. But, unfortunately, Mr. Brinley Thomas, before a joint session of Section F, Economics, and Section N, Sociology, had to note evidence of a " perverse " emigration of skilled manpower so that engineers and scientists tend to move from underdeveloped countries to the well-advanced. " The inability of underdeveloped countries to compete for the scarce supplies of skilled manpower is one of their chief handicaps."

It was against this basic picture of the world food and population situation that Sir Alexander Fleck presented his contribution to the Symposium—the only contribution of really direct interest to engineers. He felt that existing knowledge could be applied in six ways to increase food supplies.

" We could extend the area under cultivation." Obviously engineers could help here by providing machinery for clearing the land, draining marshes, and so forth, and by building roads and railways and the like. " We could give the crops more water to sustain them in dry seasons." The construction of dams and irrigation channels can be clearly envisaged. But one should not think only in terms of large engineering structures. Sir Alexander was careful to point out " There is a great need . . . . . for an efficient electric pump which will take water from a deep tube well and supply several hundred acres of land." To some extent Sir Alexander was thinking of less water too. For in the same breath he referred to the use of such pumps for land drainage and reclamation where, as in Pakistan, the rise of the water table through excessive irrigation has brought salt to the surface and killed vegetation ! " We could give them more nourishment in the form of fertilisers and manures." This involves digging up deposits of phosphates and potash and using chemical engineering techniques for the fixation of nitrogen. As those techniques involve the application of substantial amounts of power, engineers can also visualise the exploitation of fuels and the creation of hydro-electric and thermal power stations.

" We could substitute crops or varieties, animals or breeds, more productive than those which now occupy the land."

" We could improve the efficiency with which we use what crops or animals we have."

" We could modernise archaic techniques for cultivating food." The engineer will at once visualise the use of tractors and harvesters and other agricultural machinery. But Sir Alexander was at pains to point out that such a visualisation of the situation may be in error. " However pressing the world need for such machinery may be in time to come and however important a part it plays in the sophisticated agriculture of the West the call for more water and more fertiliser is at present much more urgent than for labour-saving equipment." The point is that in underdeveloped lands there usually exists a very large amount of under-employment which the use of labour-saving machinery would only aggravate until alternative employment can be provided by the erection of factories. " It would probably be of much more use to manufacture a simple bullock-drawn plough of improved design, digging a deeper furrow . . . . . or to replace the clumsy appliances now worked by hand with simple implements of sound design, light yet durable." Nevertheless he hastened to add that often more sophisticated material would be needed and he finished by saying :

" First of all, Britishers will be wanted to provide technical advice and training in field and factory at home and abroad. There are many schemes for technical aid, some under the United Nations Organisation, some under the Colombo Plan, but most of them depend for their success on finding suitable individuals willing to work in underdeveloped parts of the world ; let us hope that enough technically qualified men will be found for these jobs.

" Secondly, British technologists at home, and those who guide and support their work, can assist indirectly in the fight against hunger, by helping to develop things that are going to be needed abroad. I think we can legitimately take a broad view of this, because hunger and poverty must be tackled simultaneously, and neither will be conquered without the application of science on a broad front. Thus the development in this country of the cheapest, the simplest and the most reliable machinery and materials capable of finding useful application in underfed territories is an important part of the British contribution to the relief of hunger ; I have in mind equipment ranging in sophistication from nuclear power stations to small electric pumps, and materials as complex as some modern pharmaceuticals or as simple as ammonium sulphate. Valuable technical developments must be promptly exploited abroad.

" Thirdly, we British scientists and technologists should avoid becoming too self-centred. We should be prepared to co-operate even in technical problems not directly relevant or profitable to ourselves in Britain. I have come across in scientists here an attitude of resentment against giving away technological information to our friends in the emergent Commonwealth countries in case they exploit it to the supposed detriment of our interests at home. This, in my opinion, is a narrow and short-sighted view which, so far from affording protection, actually undermines our long-term interests and is unworthy of a country which has already given so much of technical value, and has so much still to give, to the world. We must be receptive and attentive to other peoples' technical problems and be willing to give them the benefit of our experience and our success.

" This business of satisfying hunger throughout the world is about the biggest technical challenge of our times ; it is also one which we must not fail to meet."

That last remark encourages us to look further into the future. At the Rothamstead Experimental Station in this country work has been going forward, as Dr. Harper reported to Section J, Psychology, on developing methods of preparing leaf protein as a source of human food from leafy materials which are not suitable for human consumption in their original state. Apparently the product has a deep green colour and a strange flavour " somewhere between that of spinach and hay." The author commented with undeniable truth " These and other examples stress the fact that the ultimate practical value of much of the scientific work on nutrition ultimately stands or falls upon what people are prepared or can be persuaded to eat."

Noise

In one aspect or another noise was discussed in several Sections. It was, no doubt, the growing problem of aircraft noise and the chorus of complaint from people living near airports which led to this wide interest in the subject. In discussing " Noise Annoyance and its Assessment " before Section G Professor Richards, for example, restricted himself to the problem of how to keep aircraft noises near airports down to acceptable levels. There is, of course, a major difficulty in deciding what is an acceptable level, for the decision has to be made on subjective grounds. A noise acceptable by day, for instance, may be far from acceptable by night. Nor is the matter solely one of measuring the sound level in, say, decibels. Higher frequency noises are known to be less acceptable than lower frequency ones ; with the unfortunate consequence that a jet engine which may be no noisier as measured in decibels than a reciprocating engine and propeller, but which emits sounds predominantly in the high frequency region, will prove far less easy for human beings to put up with. Another complication arises out of the tendency for there to be a " spike " of sound in the higher frequency region sticking up above the sound spectrum relating the frequency to the sound pressure level for any given source. Such a " spike " is often present when a jet engine is running well below full power and thus emitting in other respects an acceptable amount of noise. It is ordinary practice, when taking off, for aircraft to climb steeply at first out of the airport and then to throttle back for a slower rate of climb once they are flying over houses close to the airport boundary. This practice is of course based on the idea that though more people hear the aircraft, since it gains height less rapidly than it might, the noise will be less annoying because the engines are running below full power. But if the throttling back results in there being present a " spike " of sound the practice may fail of its intended effect. Moreover, the presence of such a " spike " of sound can be very objectionable when aircraft are coming in to land, because they tend to be so much nearer the ground at any given distance from the airport than when climbing away. Professor Richards also discussed the well-known sonic bang. Such bangs will inevitably be created by supersonic airliners of the future. For transatlantic flights between London and New York the aircraft might be so flown that they only went supersonic over the ocean. But Professor Richards pointed out that the use of supersonic airliners only for transoceanic travel was very unlikely. People on the ground will have therefore to get used to the bang. But nobody yet knows what degree of annoyance will be created by the bang. " Such meagre evidence as exists indicates a marginal situation which cannot be extrapolated to help a lot. Many complaints can

be traced to fear arising from unfamiliarity with the source of the bang. The evidence points clearly to the need to establish limits of bang amplitudes as a matter of urgency and to the need to introduce experimental psychologists and social scientists into a field which is rapidly expanding out of the domain in which acousticians can study the phenomena confronting them."

In fact physiologists and psychologists are already studying the subject. But they do not seem to have got very far. Professor William Burns, for example, in his Presidential Address to Section I took "The Physiology of Hearing" as his subject. He concluded that the greatest need at present is for more research into the precise relations between the different characteristics of noise exposure and the effects on the ear. In the meantime, he added, tentative relationships have to be used in deciding whether a given response to noise is, on average, harmful, and whether noise reduction, hearing protection, or other means should be used. Mr. Broadbent, before the same Section, debunked some of the allegations made about the bad effects of noise. There is no evidence that working in noisy places produces mental illness.

There is no evidence that working in noisy places requires more energy. But there is some evidence that constriction of peripheral blood vessels occurs which might conceivably be harmful, though it is not very strong.

Evidence that work carried out under noisy conditions is reduced in amount is not very convincing; but an effect in increasing human errors which appears only under high noise intensities seems well established. But having satisfactorily debunked the subject Mr. Broadbent went on to state that though annoyance is something quite different from damage to health or efficiency, it is not therefore to be taken to be unreal.

He concluded that the real effects of loud noise are quite enough to worry about without creating myths as well; and that there is nothing disreputable about trying to reduce noise simply because people do not like it.

Two other papers on the subject deserve mention here. Firstly, Mr. Roode spoke on "Auditory Fatigue and Diphasic Recovery" before Section J. We mention that paper just to show that psychologists are indeed studying the subject as Professor Richards desired they should. Secondly in Section A Mr. Curle read a paper entitled "The Generation of Sound by Aerodynamic Means." He indicated that by a combination of mathematical and physical ideas, within the last ten years or so, Professor Lighthill, now director of the Royal Aircraft Establishment, and others, have shown how the basic mechanics of aerodynamic noise production may be explained in a general way and have thus stimulated work designed to reduce noise.

There can be loosely linked with these various papers on noise one presented before Section G on "Some Effects of Low Frequency Vibration on Man" by Guignard and Irving. The rates of vibration being studied at the Royal Air Force Institute of Aviation Medicine are actually infrasonic, less than 16 cycles per second, and they are felt by the body, not heard by the ears. This low frequency vibration can cause serious discomfort and reduce the efficiency of people exposed to it. It has been found that the body or parts of it exhibit resonance phenomena particularly at vibration rates of about 5 c/s. Simples tests have been devised to measure the efficiency of men in performing tasks while subjected to vibration and they do show a falling away of efficiency. Interestingly the performance has been found to be worst during vibration not at 5 c/s as might be expected but at 4 c/s. Possible reasons for what appears to be a discrepancy are being investigated.

Withholding of Certificates by the Engineer: The Question of Arbitration

By W. H. D. WINDER, LL.M.

THE Institution of Civil Engineers' General Conditions of Contract do not often come before the courts for interpretation, but the Chancery Division of the High Court was recently called upon to construe clause 66 of the fourth edition of these Conditions in the case of *A. E. Farr Ltd.* v. *Ministry of Transport*. The clause provides that any dispute or difference between the parties shall be settled by the engineer appointed under the contract. The litigation between the contractors and the Ministry resulted from the refusal of the engineer to give his certificate when a claim for payment for a particular piece of work was made.

The contractors had agreed with the Ministry of Transport to carry out civil engineering works connected with the construction of an underpass on the London-Fishguard Trunk Road. To enable a retaining wall to be built a trench was dug along the line of the wall a width sufficient to contain the wall and to allow working space. Excavation for the structure was to be paid (under clause 16) on the basis of cubic capacity of the structure but ". . . any additional excavation which may be required for working space, &c., will be paid for under separate items," the measurement being by the area of the sides of the additional excavation. The contractors claimed to be paid during the currency of the contract for excavating working space. The engineer rejected the claim, intimating that it could be submitted after completion of the works.

The contractors' contention was that they should be paid for this work on monthly certificates over and above what they were entitled to be paid on a cubic capacity basis for excavation of the space required for the actual structure. The engineer may have been right or wrong in disagreeing with this contention. That was not the point involved in the court proceedings. The point was whether the contractors could go to arbitration without the consent of the other party to the contract and get the point authoritatively settled one way or the other. The arbitrator might or might not agree with the engineer's view but the Court had to decide whether, in view of the Conditions of Contract, the point could be put to him at that stage.

If contracting parties are dissatisfied with the decision of the engineer appointed under the contract they may, or either of them may, require the dispute to be referred to an arbitrator. But the scope of this right is limited by the following words of clause 66: "Such reference except as to the withholding by the engineer of any certificate or the withholding of any portion of the retention money under clause 60 hereof to which the contractor claims to be entitled or as to the exercise of the engineer's power to give a certificate under clause 63 (1) hereof shall not be opened until after the completion or alleged completion of the works unless with the written consent of the employer and the contractor." In the present case, of course, the employer was not consenting. He was apparently satisfied with the engineer's decision.

The reason why the monthly payments are to be made on the engineer's certificates is to enable him to say how far the contractor's claims are justified. "If only as a matter of convenience," said Mr. Justice Buckley in giving judgement, "one would not expect certificates given in good faith to be open to question, particularly having regard to the wide and arbitrary powers conferred on the engineer by other provisions of the contract. The alternative view would open the door to constant references to arbitration during the currency of the contract. Interim certificates of this kind are not final and conclusive determinations of rights, as clause 60 (4) makes clear, and for this reason also are not likely to have been intended to be the subject-matter of arbitration while the contract is running." It might be added that the reference to the engineer's "arbitrary" powers merely implies that he has an untramelled discretion in reaching his decision. There is no implication in the lawyer's use of this adjective of something reprehensible or tyrannical.

References to arbitration during the currency of the work are thus meant to be exceptional. But Mr. Justice Diplock concluded that the contractors in the recent case did have the right to go to arbitration at that stage as the engineer had refused to include certain claims in his certificate and might thus be said to have "withheld" his certificate within the wording of clause 66 of the contract. The dispute between the parties was not about measurements. It was about something more fundamental.

It was held to be a dispute as to the withholding of the certificate because it was a dispute which related to something in consequence of which a certificate ought, in one view of the law, to have been given. If an engineer, acting in good faith but in accordance with mistaken principles, because he has misdirected himself about the law, refuses a certificate altogether or refuses to certify more than a proportion of a proper claim, he would be "withholding" a certificate within the meaning of the contractual conditions. This is the exceptional type of case. The normal type of case arises when the engineer, in exercising his discretion, gives a certificate for a lesser sum than that claimed. Then he cannot be described as withholding anything and a party cannot insist on going to arbitration until the completion of the works. The distinction laid down in the case of *A. E. Farr, Ltd.* v. *Ministry of Transport* should not be difficult, for the future, to apply in practice.

LETTERS AND LITERATURE

Letters to the Editor

ABNORMAL LOADS BY ROAD

SIR,—I was most interested to read your leader in the issue of August 19, dealing with "abnormal loads by road." Obviously it is necessary to impose restrictions on maximum dimensions and weights of loads moved by road, but it does seem odd that a combination of 150 tons and 80ft length of load and vehicle should have been selected.

As is well known, when loads approach a weight of 100 tons the trailer on which the load is carried is moved by two tractors arranged either to double-head or one at each end. Such an arrangement immediately exceeds the 80ft maximum yet the load may only be about 60 per cent of the maximum permitted.

Might it be suggested that the maximum length should be about 100ft ? This would bring the three stated maxima into a logical combination and undoubtedly remove an ambiguity in proposed regulations.

D. G. MORGAN

Birmingham,
September 6, 1960.

INDUSTRIAL VALUE OF D.S.I.R. RESEARCH

SIR,—In the issue of THE ENGINEER dated April 29, 1960, you stated that you would welcome letters from firms which had made use of the D.S.I.R. Research Reports such as those surveyed in your article. We have now had operational experience to confirm some related work and trust that even at this date the following notes may be of interest in the particular case of the valve designs which were described.

Some time ago we were faced with the problem of designing a valve to throttle the output of large boiler feed pumps on our test bed. The requirements of such a valve were :

(1) To break down the discharge pressure of the pump from anything up to 3500 lb per square inch to 40 or 50 lb per square inch and to give approximately linear adjustment over this wide pressure-drop range.

(2) To dissipate the corresponding energy at a rate of anything up to 3000 h.p. in as small a space as possible, and to ensure establishment of orderly flow within a very few pipe diameters after the valve. This requirement was particularly important in view of the fact that pumps are tested on what is virtually a closed circuit, and space requirements prohibit an extravagant straight length of piping up-stream of the flow measurement equipment.

We studied the valves designed by N.E.L., particularly valve type 2, as well as a smaller valve by another maker, which we had previously used for this purpose. The final outcome of the study was the valve shown on the drawing below. The water enters through the side branch and is throttled as it flows radially inwards through holes in the cylindrical plug. An innovation here is that instead of using a single spiral pitch line as for the N.E.L. valves, we utilise a two-start spiral in such a way that each hole has a partner which is exactly diametrally opposed to it. Thus, jets issuing from each opposing pair of holes mutually stagnate each other when they meet at the centre of the cylindrical plug. This eliminates, to a large extent, erosion of the valve body by high velocity water, which we have found a serious source of trouble in other types of valves. Over the past few months we have had sufficient operating experience of this new valve to be able to state that it creates less noise and turbulence, is easier to adjust and gives closer control of the flow than any other energy dissipating valve which we have previously employed.

It should be appreciated that, while in original conception the valve has many similarities to that described in the N.E.L. Report, it differs in respect of several important features which have been introduced as a result of our past experience with other valves used for the same purpose.

G. F. ARKLESS

Chief Designer
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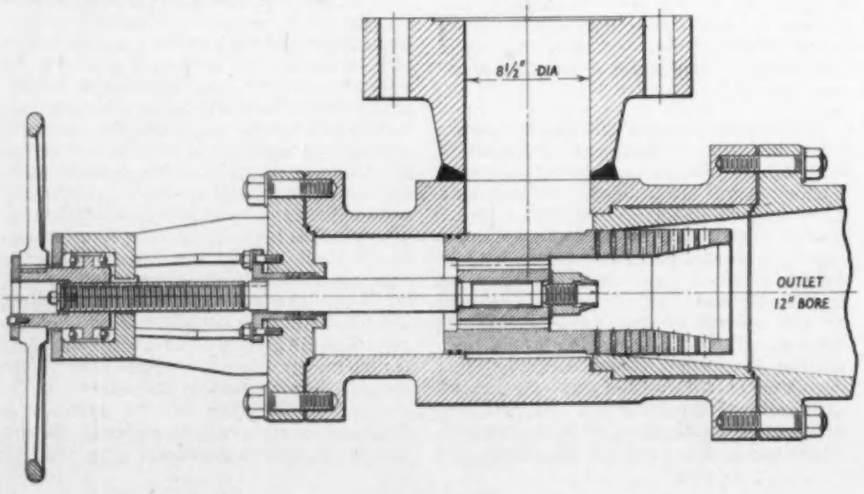


Book Reviews

Roll Pass Design. United Steel Companies, Ltd., The Mount, Broomhill, Sheffield, 10. Price 60s.

THIS book—one of a series of technical works published by the United Steel Companies—has been compiled by Mr. J. B. Orr, of the Rolling Mill Section of the Company's Research and Development Department, with Mr. James Thorburn as a consultant. The author has also had the assistance of an editorial panel of company staff experienced in roll pass design ; in particular Messrs. J. S. Armstrong, E. Bailey, E. L. Burgess and J. McLauchlan are named in the preface.

Like the other books in the series, this one has a thoroughly practical approach, though this is not to suggest that the theory of the subject is not adequately covered. On the contrary, theoretical considerations, from many sources, are the basis of the problems discussed and the designs proposed. But the roll designer has to meet many requirements. Modern rolling mill plant is very costly, and must be kept operating at maximum production rates ; the cost per ton of the product must be kept as low as possible, while the quality must be consistent and to the standard demanded by the customer. Often, the various requirements will be in conflict, and the roll designer has to find a compromise which will be acceptable to all concerned.

The book has a two-fold purpose. In the first place, it is designed to provide up-to-date information on the basic principles of roll pass design and to illustrate these principles by means of specific examples of common rolled products. Secondly, it is intended as a text book for trainees in the business of steel rolling.

In the latter connection the introductory chapters are particularly useful. Rolled products are defined, the history of rolling is surveyed briefly, and the theory of hot rolling is discussed at some length. From this introduction, which the more experienced man can ignore if he wishes, the student can progress easily to the more abstruse problems of roll pass design. There he will find, as the preface warns him, that the book is not easy reading at times. But, of course, it cannot be easy reading. Roll pass design is not an easy subject, and the book would have failed in its object if it made it appear so. The author has done all he can to make the subject clear by a well-written text and a generous provision of drawings. A very large amount of specialised knowledge, not easily obtainable elsewhere, is presented in a concise and logical manner in this book, and the United Steel Companies and its staff are to be congratulated for making them available.

The Birth of the Steamboat. By H. PHILIP SPRATT. Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C.2. Price 28s.

MR. SPRATT'S name is well known to students of steamship history, who will welcome another of his specialised studies. To such students it is only necessary to say that the book is a typical product of the author—it is simply and logically arranged

to show, in chronological order, how the steamboat developed from early fancies and aspirations, through practical experiment to technical and commercial success. At that point the present book leaves the subject. "From childhood to adolescence," as the author puts it, is a long story, with many false starts and many disappointments for early projectors.

The book is first and foremost a technical history and—a point which the student of history will appreciate—it is very well annotated. There are, in fact, nearly 400 source references, a perusal of which will show how far the author has ranged in his search for facts. That essential feature of a good reference book, an adequate index, is provided, too.

But a reference book, though it may satisfy the student of the subject, can easily be very dull. This book avoids that pitfall. It is quite readable as a straightforward story. Source references are there for those who want them, but as they are grouped at the end of the book, they do not irritate the reader who finds footnotes distracting.

Destillier-und Rektifiziertechnik. By EMIL KIRSCHBAUM. Berlin-Göttingen-Heidelberg: Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM.48.

IN the present third revised edition of *Distillation and Rectification* (first published 1939), the author has broadened the treatment of the physical and theoretical basis of the subject, including those design and operating developments which have proved their worth and importance since the appearance of the second edition eleven years ago. While the time seems ripe for the publication of a multi-volume compendium on the subject, the need for this has lessened with the appearance of monographs independently treating a number of subordinate fields. This fact decisively influenced the approach to the present revision, in which much thought has been expended in treating the subject in the most up-to-date manner and as concisely as possible.

Several of the problems listed as tasks for future research in the previous edition have since yielded to further scientific effort. The most important recent results discussed here include the theoretical treatment of rectifying columns, permitting the calculation of the column section in terms of dimensionless factors involving all the relevant physical and design quantities. Further researches carried out at the author's institute and elsewhere deal with the detailed performance of rectifying columns.

Handbook der Werften, 1958. Edited by PROFESSOR DR.-ING. K. WENDEL. Hamburg: Schiffahrts-Verlag "Hansa" C. Schroedter and Co., Hamburg 11, Stubbenhuk 10. Price DM.36.

THE present fifth edition of the *Handbook of Shipyards* again contains, in its technical section, information on a number of subjects of interest to designers and ships' surveyors, and in this way supplements the preceding four volumes. The handbook constitutes part of a comprehensive series of publications in which all aspects of naval architecture and marine engineering are to be dealt with or have already been considered; a detailed subject index to all five volumes which have up to now appeared is contained in the present edition. Much space is devoted to the section "Completed Ships" in which will be found the principal plans and numerical data of a number of typical freighters, tankers and passenger vessels; this compilation of German design is the first of such comprehensiveness which has appeared in the last thirty years, and will be found to be of particular practical interest. This section also contains a survey of United States standardised designs from the C_1, C_2, and C_3 ships to the "Liberty," "Victory" and "Mariner" classes. In the field of naval design, the section on ships for inland waterways by Dipl.-Ing. Krappinger is continued from the preceding volumes and deals with stability, main machinery and fitting-out. A contribution by Dipl.-Ing. Domes is concerned with the calculation of light-alloy designs. Dipl.-Ing. Ehmsen surveys the German building programme of two-stroke marine diesel engines, and supplements previous information concerning couplings and gears. A detailed section by Dipl.-Ing. Heil and Professor Wangerin is devoted to electrical propulsion, its basic principles and specific actual designs. The last two sections again contain a detailed index of all West German and West Berlin shipyards, their installations and recent completions, as well as the principal shipping organisations and institutions.

Instrument for Measuring Very Small Bores*

By P. W. HARRISON and G. M. SEVERN

In a previous article [1] there appeared a description of a prototype instrument for measuring the diameter of very small bores. Reference was made in it to further development work, and this note describes the modifications and additions since made to this instrument.

Previously, movement of the workpiece in relation to the stylus was made by hand-operation of the horizontal cross-slide, and considerable care was required to avoid all strain on the assembly while so doing. This difficulty has been met by the use of a small synchronous electric motor to drive the worm shaft. The motor and worm assembly are mounted on a bracket which, by rotation of a cam, can be engaged or disengaged with the worm wheel, thus enabling coarse adjustments still to be made by hand. A simple cam and pawl arrangement operating on the motor shaft determines the direction of its rotation, which is at the low rate of 6 r.p.m. In this way the motion necessary to set the workpiece in correct relationship to the stylus can be effected without the application of forces external to the instrument.

It was apparent that, if the change in anode current in the d.c. circuit which arises from the making and breaking of the contact between stylus and workpiece could be made to operate a relay, then as a further development, the latter could be introduced into the motor supply to cause the traverse motion to halt at the moment at which the stylus stands in correct relationship to the workpiece. The circuit so modified is shown in the accompanying diagram. A switch by-passing the relay enables the motor to be energised when the stylus is out of contact with the bore should this be desired. Examination of the circuit will also reveal that the resistances in the grid bias circuit have been substantially increased; in particular, a resistance of 2·2MΩ has been placed close to the stylus. This was found necessary due to some interaction between the a.c. and d.c. circuits which produced very slight welding between stylus and bore. Due to the very slow traverse rate, no difficulty has been experienced with over-run of the slide.

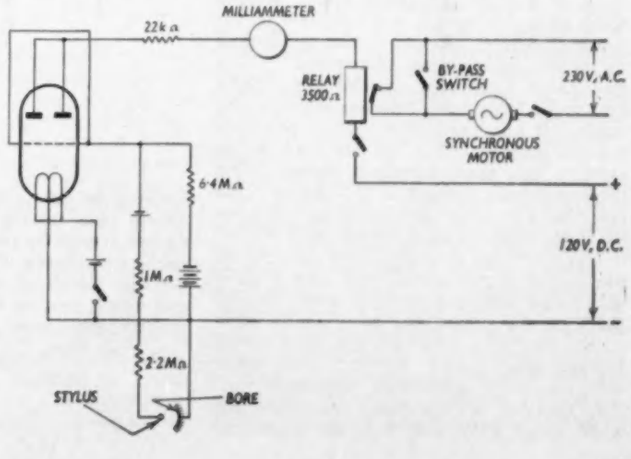
Another development has been the construction of an even smaller stylus comprising a ball of 0·014in diameter mounted on a tungsten stem. This has extended the working range of the instrument down to bores of 0·02in diameter. For strength, the reduced end of the stem enters a hole in the ball made by electrolytic erosion (not to be confused with spark erosion) using a technique based upon that described by A. Uhlir [2]. In the course of experimental work using this technique, holes down to 0·0008in diameter have been successfully made in balls of about 0·014in diameter, about five minutes being required to make a hole passing completely through the ball.

The work described above has been carried out as part of the research programme of the National Physical Laboratory and this note is published by permission of the Director of the Laboratory.

*Communication from the National Physical Laboratory.

REFERENCES

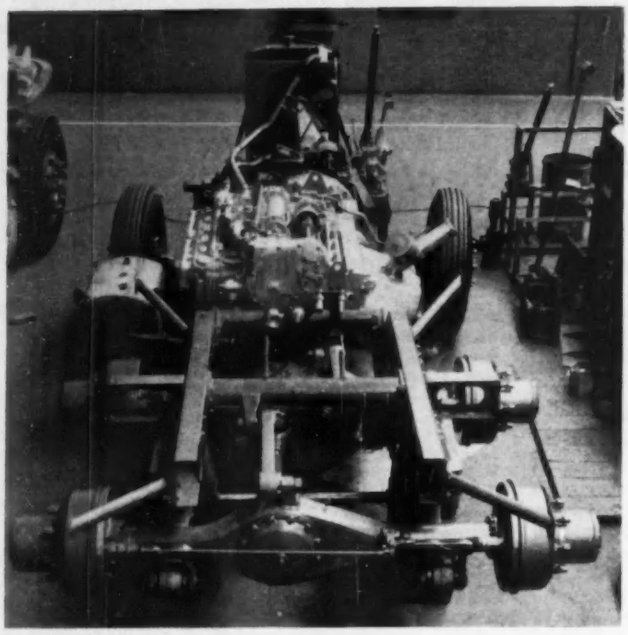
[1] Harrison, P. W., and Severn, G. M., THE ENGINEER, 1959, 207, 851.
[2] Uhlir, A., Junr., *Rev. Sci. Instr.*, 1955, 26, 965.



Modified circuit for control of the synchronous motor driving the worm shaft

Heavy Vehicle Innovations

There have been announced by Scammell Lorries, Ltd., both new vehicles and significant improvements on existing designs. Higher performances in both braking and accelerating have been attempted.



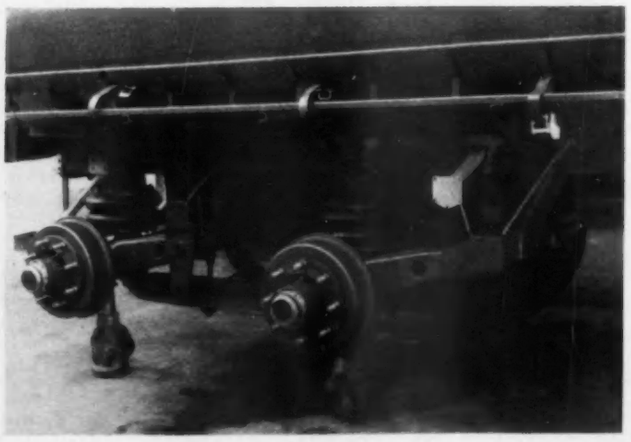
The prototype "Trunker" under construction. A Hendrickson bogie carries two Albion hub reduction axles, driven from a transposing box at the far end of the power unit. The gear lever stretches up from the near side of the box, and at the bottom of the brake lever can be seen the hydraulic pump. Prominent on top of the engine oil filter spout is the centrifugal filter

THE "Trunker," as the name suggests, is a heavy vehicle suited for long hauls at high speeds. The conventional maximum-weight articulated vehicle has only one driven axle and a rather small part of the load resting on it : on slippery surfaces both the traction and the stability are critical. The new tractor has three axles, the two in the rear bogie carrying a large part of the weight of the trailer and being both driven. To attain the performance required overseas and on motorways in this country, a powerful engine was necessary, and had to be accommodated either below the front of the trailer or in the cab. The latter solution was deemed prejudicial to the performance of the crew, and the engine was placed in the middle of the vehicle : a Gardner 6LX was selected on account of its good standing with operators, and because of its size the horizontal version, normally installed underfloor, is used. Considerations of tyre life and brake balancing ruled out the Scammel arrangement of a single differential and a walking beam each side, and it was preferred to use a pair of Albion "Reiver" axles rather than to adopt independent suspension. This meant that a propeller shaft of some length had to be interposed between gearbox and bogie : it was obviously more attractive to put the gearbox under the cab than in the extreme tail, even though it meant fitting the engine back to front. The "Reiver" has the splitter box on the frame and separate propeller shafts to each driven axle, but the "Trunker" has a single shaft carrying all the power to the centre axle and a third differential mounted on this axle ; helical gears on the pinion and relay shafts effect a reduction of 1·216 from the input speed. Having gear trains between both axles and the third differential contrasts with the Leyland arrangement described last week (page 435) and has the advantage that the final drives are identical. The lock on the third differential is operated by a linkage from an air motor. The ends of the axles are located by a balance beam and the torque reactions taken out by tie rods above the differentials ; all pivots are rubber bushed and require no lubrication. The only springing at the rear is a set of four Hendrickson rubber cushions, giving a suspension frequency of 265 cycles per minute at full load.

The auxiliary services are comprehensive. There is, of course, an electric system, 24V with d.c. generator. There is also a compressed air system to supply two separate Clayton Dewandre "Airpak" units (see page 209, July 29, 1960) ; one unit brakes the front and centre axles, the other the rear and, by an air line, the trailer—there is a relay valve on the trailer to minimise the delay associated with signalling long distances with air. The power take-off on the gearbox drives the cooling fan constantly (except in the neutral between first and reverse) and, when required to operate equipment on the trailer, a Deri Sine hydraulic pump. Provision has been made for power steering. Clutch operation is hydraulic but not powered. There is no centralised lubrication system ; nipples are confined to the steering linkage and the propeller shafts.

The increased loading of the trailer coupling has necessitated a new Scammell design ; it is not intended to be quickly detachable, and it allows a certain amount of roll against rubber bushes. The trailer bogie is, like that of the tractor, non-reactive ; each wheel is carried on a trailing arm, which takes all forces other than the vertical reactions, and on each side a beam that passes under the rear trailing arm is linked to the ends of each arm. The arms are relieved of the weight of the vehicle by Firestone air bellows, the front and rear bellows each side being connected together to balance the load on the two wheels. The beam joining the trailing arms serves two purposes : it averages the wheel deflections on each side and passes the result to the suspension control valve, and it is connected to the frame by a rubber spring and thus renders the suspension harder, at least with an empty trailer—this rubber springing will tend to suppress any tendency for the suspension to become asymmetrical when running along a camber. This bogie also has rubber bushes at all pivots. While limited to 24 tons g.v.w. in this country, the "Trunker" can be uprated to 28 or even 30 tons gross with twin tyres on the driven bogie.

The "Handyman" is more conventional ; it is, like the familiar "Highwayman," an eight-wheeled articulated outfit, but to allow a longer trailer the tractor is forward control. A Leyland O.680 engine drives a Scammell gearbox with clutch stop ; clutch operation is hydraulic and not powered. The greater weight on the front wheels is mitigated by taper roller thrust bearings in the steering swivels. The braking is purely air powered from the foot pedal, and mechanical on the driven wheels by the single-pull hand lever. The cab is a new design of lesser length than the Motor Panels cab generally used in forward control vehicles of the Leyland Group ; the part above the mudguards is easily detachable, all the electrical connections being by plugs and sockets. The cab is built of glass-fibre-reinforced plastic. Jacking, braking, and coupling of the semi-trailer are executed automatically by air power. The trailer has another example of a non-reactive bogie ; the geometry is similar to that of the air sprung trailer, but the springs are stacks of rubber discs. The wheel loads at each side are taken by supporting the tops of the springs,



Trailer air suspension ; the rebound stop restraining the beam between the axles can be seen, together with the light linkage to the level control valve, but the auxiliary rubber spring is not fitted

not against the frame, but by links from the end of the beam, which now carries almost the whole of the vertical reactions (excluding the unsprung weight) into its pivot below the frame. The suspension frequency at full load is 200 cycles/min.

A non-reactive geometry has also been evolved for those trailers which formerly had the rubber suspension introduced by Scammell in 1933. Many of the parts are common and it is expected that operators will purchase kits to convert existing vehicles, although this does entail fitting a new transverse member in front of the bogie to carry the trailing (erstwhile leading) arms locating the front wheels of the bogie. This suspension is seen in our illustration ; it can be distinguished from the suspension of the " Handyman " trailer by the latter having one large stack of discs for each wheel.

Interestingly enough, the revived Scammell rigid eight-wheeler, now known as the " Routeman," does not use a non-reactive geometry for its leaf-sprung axles.

Some Technical Aspects of Satellite Communication

Results achieved with the " Echo " communication satellite were described, and future developments in this field foreshadowed, in a paper presented last week to the Thirteenth General Meeting of the International Scientific Radio Union in London by J. R. Pierce of the Bell Telephone Laboratories. Some abstracts from the paper are given below.

AT present the total bandwidth of all overseas Bell System telephone circuits, including short-wave radio as well as under-sea telephone cable, is only about a megacycle. In contrast, the backbone microwave and cable routes cut by a north-south line across the United States provide telephone and television channels having a bandwidth of over 100 megacycles. Submarine cables are not uneconomical by the standards of narrow-band systems ; they simply do not afford the economies of very broad-band systems. The bandwidth of submarine cables is sure to increase, but the bandwidth of microwave systems seems inherently greater.

Satellites as repeater sites would enable one to cross an ocean in just two hops—up to the satellite, and back down again. A satellite system would be most useful for long and difficult communication paths which would justify developing and operating a new system of large initial cost.

The present cost of launching even comparatively light satellites appears to be several millions of dollars. However, large vehicles of the future might launch large satellites, or might launch many smaller satellites at one time for a much lower cost per satellite. The undetermined useful life of satellites is perhaps the greatest source of uncertainty in satellite communication costs. A difference of useful life of two or three to one would cause a large cost difference. To provide economically feasible communication, satellites must last for some years, the longer the better.

" Echo " is a National Aeronautics and Space Administration satellite communication project in which the Bell Telephone Laboratories is participating. A 100ft dia., 130 pound aluminised plastic balloon was launched on August 12, 1960, in an orbit 1000 miles high, reaching an extreme latitude of 48 deg. A 10kW, 960·05 megacycle transmitter at Bell Telephone Laboratories' Holmdel, New Jersey, location illuminated the balloon, and the reflected signal was received at the Jet Propulsion Laboratory's Goldstone station in California. Goldstone illuminated the balloon at 2390 Mc/s and the reflected signal was received at Holmdel. The Naval Research Laboratory's station at Stump Neck, Maryland, also participated in the " Echo " experiment, transmitting and receiving on 2390 Mc/s.

During the " Echo " experiment radar data from Goldstone, from Lincoln Laboratory's Millstone Hill radar in Massachusetts, and from other sources is transmitted by teletypewriter to the Goddard Space Flight Centre in Washington. There the orbit of the satellite is computed. Data is also computed for pointing the antennas at Holmdel and at Goldstone, and the data is received at those locations *via* teletypewriter as punched paper tapes. Each tape gives, for each two seconds : time, azimuth, rate of change of azimuth, elevation, and rate of change of elevation. The received tapes are fed into a digital-to-analogue converter which is equipped with an accurate clock. As each time corresponding to a time on a tape is reached, the converter reads out the angle and rate information and controls the antenna pointing direction and motion accordingly.

This tracking system was tested by tracking the " Tiros " weather satellite, which is mutually visible at the east and west coasts for only about two minutes. The satellite was successfully tracked at both coasts (and at Stump Neck), and for 110 sec. a faint but detectable 960 Mc/s signal sent out by the Holmdel transmitter and reflected by the tiny satellite was received at Goldstone. Optical and radar tracking are available as corrections to or as replacements for this computed tracking.

Even the signal reflected by a 100ft balloon 1000 miles high is very faint. For useful signals, very sensitive receivers and large antennas must be used. At Goldstone an 85ft parabolic dish antenna and a parametric amplifier receiver are used. This receiver has a noise temperature of about 300 deg. K ; it is only about a tenth as noisy as conventional receivers using crystal mixers. At Holmdel an even more sensitive three-level maser receiver is used. The maser receiver is so sensitive that even a fraction of the microwave radio noise due to the heat of the earth would seriously reduce its effectiveness. The noise accepted by the side and back lobes of an ordinary parabolic dish antenna would be intolerably high. In order to use the maser receiver effectively, a large horn reflector antenna was built at Holmdel.

For the most favourable part of the " Echo " satellite orbit, the signal received at Goldstone during these experiments is about 22 dB above the noise in a 6 kc/s band. The signal received at Holmdel is about 32 dB above the noise in a 6 kc/s band. For the most unfavourable position of visibility the signal will be almost 10 dB weaker. These signal-to-noise ratios are too low to give a good quality telephone circuit.

By using a broader-band signal it is possible to improve the signal-to-noise ratio of the received message without increasing the transmitter power. One way of doing this is to use frequency modulation. When an ordinary f.m. receiver is used, the bandwidth of the receiver must be increased as the frequency deviations of the transmitted signal are made greater in order to receive the widely varying signal frequencies. But, increasing the bandwidth of the receiver admits more noise, and if the bandwidth is made too wide the noise will cause the system to " break."

Fortunately, a number of years ago J. G. Chaffee invented an f.m. receiver which overcomes this difficulty. This receiver responds to a narrow band of frequencies only at any instant, but the frequency to which it is tuned tracks the transmitted frequency as the f.m. transmitter is modulated. This is called an f.m. with feedback receiver because a negative feedback circuit is used to keep the narrow band receiver tuned to the received signal. Despite the use of a frequency deviation of 10 times the base bandwidth, such a receiver can function satisfactorily with a 12 dB signal-to-noise ratio in an i.f. amplifier having a bandwidth about twice the base bandwidth.

The use of an f.m. with feedback receiver in the " Echo " experiment makes possible a 20 dB improvement in the signal-to-noise ratio of the received 3000-cycle bandwidth voice signal by using a ± 30 kc/s frequency deviation, with adequate margins against the system breaking. During the " Echo " experiment, signals have been transmitted from Holmdel *via* the moon to Goldstone and to Jodrell Bank in England. Because of the multipath nature of signals received from the moon, wide deviation f.m. is poorly suited to this use, but good signals have been obtained and recorded on magnetic tape at Goldstone using a single side-band.

During the course of work on Echo we had a vivid experience of interference with a ground microwave system. The microwave relay system of the New Jersey Turnpike operates in two bands : 953-960 Mc/s, and 1925-1965 Mc/s. There are nine receivers in the state in the lower band, operating at various frequencies to lessen the effect of over-reach. The New Brunswick receiver, 15 miles from Crawford Hill, operates at a frequency of 959·7 Mc/s with a nominal band of 0·5 Mc/s, for transmission of telephone and teletype, while our transmitter operates at 960·05 Mc/s. While the operation of these systems is theoretically compatible, it was found that when our transmitter radiated more than 3kW in any direction it completely knocked out the New Brunswick receiver. It also knocked out a like receiver at Secaucus, 26 miles from Crawford Hill, despite the fact that the Secaucus antenna was pointed directly away from our transmitter. A rearrangement of the Turnpike system frequencies overcame the difficulty.

Passive Satellite Systems

If the " Echo " experiment shows that balloon satellites are enduring enough, passive satellite systems will become technically feasible for broad-band transoceanic communication. Around 20 satellites in somewhat random 3000-mile high polar orbits could provide a commercial grade of broad-band service between Newfoundland and the Hebrides, and a somewhat greater number could provide service between New York and London or the Continent. Such satellites

could be used at different locations for transoceanic communication over many other paths.

To attain a 5 Mc/s bandwidth suitable for 600 telephone circuits or one television channel, antennas over a hundred feet in diameter and several tens of kilowatts of transmitter power would be required. This presumes the use of a maser receiver and of wide deviation f.m., together with an f.m. with feedback receiver. The radio frequency band required for one-way transmission would be about 100 Mc/s, and two-way communication, allowing some guard band, would require a bandwidth of around 250 Mc/s.

Active Repeaters

The size of the ground antennas and transmitter power required for satellite communication could be reduced by the use of active repeaters. Suppose, for instance, that an active repeater at a height of 2500-3000 miles radiated a power of 1 watt essentially isotropically at a frequency of 6000 Mc/s. Such a repeater could use an antenna with a dipole radiation pattern, and it could be spun to keep the axis pointing in a known direction. Let us assume that wide-deviation f.m. with a bandwidth of a little over 100 Mc/s is used to transmit a base-band of 5 Mc/s. If a maser amplifier and a 60ft aperture horn reflector were used on the ground, together with an f.m. with feedback receiver, a signal-to-noise ratio of 50dB would be attained. Because the satellite receiver would be more noisy than the maser receiver used on the ground, the power used to transmit from the ground to the satellite should be higher than the power used to transmit from the satellite to the ground. Assuming a 60ft horn reflector antenna, a transmitter power of 1000 watts would suffice.

In order to avoid feedback from the transmitter on the satellite to the receiver on the satellite, it would be necessary to receive on one band of frequencies and to transmit on another band. Thus, one-way communication would call for about 250 Mc/s bandwidth and two-way communication for about 500 Mc/s bandwidth. Ultimately, for reasons of economy and capacity, it would be desirable to put equipment for several channels aboard one satellite, so that a frequency band of several thousand megacycles would be used in connection with one satellite.

The ground equipment for such a system is within reach. Satisfactory horn reflector antennas can be built. A travelling-wave tube can supply the power required, and will have sufficient bandwidth. The same tracking means used in " Echo " will suffice.

The immediate technical problem in such a system is satellite life. To-day we know of no way of making long-life microwave tubes with powers of around 100 watts. High powers call for high cathode current densities, and high cathode current densities mean short life. We believe, however, that a 1 watt travelling-wave tube can be made with an assured life of 10 years or more, and such a tube is under development at the Bell Telephone Laboratories. The design relies heavily on experience with a 5 watt tube for the same frequency. Twelve of these 5 watt tubes have been on life test for four years, and all still operate satisfactorily.

The economic advantage of low power is great. The weight of the power source required, which is the dominating part of the satellite weight, is proportional to the power. Use of low power transmitters enables one to launch more satellites or satellites providing more communication channels (more transmitters) for a given cost. Further, using a low transmitter power and a broadband form of modulation one requires only a comparatively low signal-to-noise ratio in the radio frequency band. Thus, if interference from ground microwave systems is eliminated many satellites could operate in different parts of the sky simultaneously on the same radio frequency band, interference being avoided by means of the directivity of ground station transmitting and receiving antennas.

Aside from the travelling-wave tube, it seems possible to construct a broad-band satellite receiver and transmitter entirely out of long-life solid-state components. We believe that a long-life highly reliable power supply can be constructed using solar cells, nickel-cadmium storage batteries and transistor inverters.

To survive the radiation of space, solar cells must be protected by transparent covers of quartz or other material ; around a tenth of an inch seems called for. While the damage of known radiation to solar cells has been measured, data on amount, nature and variability of radiation at various altitudes is inadequate. Nickel-cadmium storage batteries can have a long life if excessive charging rates are avoided and if a hermetic seal is maintained in order to avoid evaporation of the electrolyte. We are working on an active satellite repeater of the sort described above.

While we are investigating the possibilities of passive satellites in the " Echo " experiment, they have the disadvantage of calling for very large ground antennas and very powerful ground transmitters, which would have to be separated by phenomenal distances in order to avoid interference. Further, the life of fragile balloon satellites has not been evaluated and may be unsatisfactory.

Further research on passive satellites is desirable. In the light of our present knowledge, however, active satellites appear superior to passive satellites for commercial communication because they will provide more economical communication and because they will reduce interference problems and allow more satellite terminals to operate on the same frequency.

Orientation and Station Keeping

By spinning a satellite, the axis of spin can be kept in a fixed direction—perpendicular to the plane of the orbit, for instance. Such spin orientation cannot be used to point an antenna on a satellite directly at the earth. The direction between the satellite and the centre of the earth changes as the satellite revolves around the earth.

A satellite can be given a fixed orientation with respect to the surface of the earth by means of gas jets and motor-driven flywheels controlled by electronic equipment. It was assumed earlier that a large number of satellites were launched into " random " orbits having slightly different periods, so that, by chance, almost always at least one satellite would be mutually visible at the two ground terminals. By using electronically controlled gas jets, station keeping could be achieved. That is, a satellite could be kept in some exact relative position with respect to other satellites.

While satellites have been oriented for brief periods, at present long-life orientation or station keeping equipment does not exist. We do not contemplate the use of orientation or station keeping equipment in connection with our early satellite experiments ; we will rely on spin orientation, which is quite satisfactory for dipole antennas.

Further, in the case of satellites in orbits a few thousand miles high, orientation and station keeping equipment may not be advantageous. Their weight cuts down on the communication equipment which could be launched. Further, the use of orientation and station keeping equipment would almost certainly reduce satellite life. It may well be most economical to launch many spin-oriented satellites in random orbits rather than fewer satellites including orientation and station keeping equipment.

" Stationary " Repeaters

So far we have discussed repeaters at comparatively low altitudes, which move with respect to the surface of the earth and must be tracked by receiving and transmitting antennas. A multiplicity of such satellite repeaters would be necessary in order to assure uninterrupted service. A repeater in an equatorial orbit about 22,000 miles above the earth, revolving in the same direction as the earth's rotation, would stand still over a point on the earth's equator. Such a repeater would be visible over more than one-third of the earth's surface. It would require orientation and station-keeping equipment.

Assuming oriented antennas, the 1 watt repeater, that would serve at an altitude of 2500 miles with an essentially omnidirectional antenna, could also be used at 22,000 miles with a beamwidth just covering the earth. It will take much research and development to provide such equipment, and we will not have it as soon as we will have long-life spaceborne microwave equipment and power supplies for unoriented active repeaters.

The stationary repeater has a disadvantage for telephonic communication. The propagation time to and from the repeater is about 0·3 sec. Thus, a speaker cannot receive a reply to a remark for about 0·6 sec. Tests indicate that this delay does not interfere with a telephone conversation if a four-wire circuit is used, that is, if completely independent paths are provided from each transmitter to each receiver. Actual telephone circuits, however, always include two-wire links, over which one both talks and listens. When a delay of 0·6 sec. is included in such a circuit, an intolerable echo precludes use. To get rid of the echo one must use an echo suppressor which interrupts transmission at one end while the party at the other end is talking.

Echo suppressors do not seriously interfere with a conversation when the round-trip delay is less than 0·1 sec. Preliminary experiments show that circuits with 0·6 sec. delay and echo suppressors are objectionable to a large fraction of users, and that conversation is sometimes brought to a halt by both users speaking at once. Only further investigation will show how serious this really is. It has been proposed that one might talk to the antipodes by sending a signal to one stationary satellite, back to the ground, to another stationary satellite, and thence to the antipodes. This involves a round-trip delay of over a second. Preliminary experiments indicate that such a delay is nearly intolerable.

We are studying the delay problem further ; we do not have final answers yet. Although the stationary repeater holds considerable promise for the future, it seems considerably further away than the low-orbit active repeater. Moreover, a very satisfactory world-wide communication system could be provided much sooner by the active repeater in random orbit.

Automatic Testing Jig for Domestic Switches

An application of cold cathode triodes to a logic circuit for controlling a sequence of test operations. Four tests are made, and the circuits detect various types of fault, initiating the action of a pneumatically-powered sorting mechanism.

VARIOUS static control equipments have been developed by The General Electric Company, Ltd., which make use of cold cathode triodes, magnetic amplifiers and transistors, either separately or in combination. A typical application of equipment using cold cathode triodes is in an automatic domestic switch testing jig installed at the Witton Works of the company's Engineering Group. The jig (Fig. 1), designed and developed by the company's laboratories at Witton, is being used for testing individually the " Clipper " switches which are the latest addition to the G.E.C. " Mutac " range of domestic switchgear. The equipment is capable of performing four separate tests on every switch to prove that : (1) the circuit is made with the switch in the closed position ; (2) the switch does not break the circuit too early in its travel ; (3) the switch does break circuit ; (4) the switch will re-make the circuit, and the dolly will return to the " On " position by itself from the point of break.

The switches are tested at normal voltage and at 20 per cent over-current, at a rate of approximately one per second. Faulty switches are sorted and distributed to four separate bins and automatically counted. Satisfactory switches are fed to a box in front of the machine. Logic circuits incorporating cold cathode discharge tubes are used for detecting the various types of fault and for initiating the sorting movements, which are then carried out by a pneumatically-powered mechanism.

Among the problems of design, two presented great difficulty. The first was that the point at which the switch should break circuit had to be not less than 3 deg. from the " at-rest " position of the switch dolly when " on." As the dolly rest position was a variable quantity, because of manufacturing tolerances, this required that the datum point for the 3 deg. measurement be automatically adjusted for each switch. The second problem arose in the test for re-making from the point of break. This necessitated reversal of the movement of the dolly drive mechanism with negligible overtravel.

Fig. 2 illustrates the mechanical system adopted in the jig. The pivoted lever *A* takes up a position determined by the switch dolly. The main driving lever *B* is moved anticlockwise, pivoting about the fulcrum F_1. Link *C* is thus moved to the left and, by wedge action, locks lever *A* relative to the main lever. The whole then rotates anticlockwise about F_1, operating the switch. The travel of the switch dolly is then measured as the movement of the platform *D* from a fixed point. To ensure positive locking of the lever *A*, the platform movement is restrained by a spring.

In Fig. 3 the switch on test is operated by a lever system driven by a double-acting air cylinder *X*. To ensure precise position control, the movement of the piston is controlled by a hydraulic piston in cylinder *Y*, which forces oil around a closed circuit via a variable valve. A large ratio of movement is obtained by the use of a ramp *E* and roller, and by the length of the arm *B* which pivots around fulcrum F_1. Current is fed to the switch under test by means of two electrodes carried on a flap *G*, pivoting around F_2, which is operated by the air cylinder *H*. After test the switch is ejected and falls into chute *J*. Situated along the length of this chute are four trap doors operated by air cylinders *K* (the last one is shown open). If a switch is faulty the appropriate trap door is opened by a signal from the electronic circuit, and the switch falls through into a reject bin *L*. Beneath each trap door is a pivoted platform *M*, which is struck by the falling switch and then operates a microswitch *N*, to provide a resetting signal to the air cylinder. A switch which is satisfactory passes unimpeded throughout the length of the chute to a bin *P*. Other microswitches detect flap position.

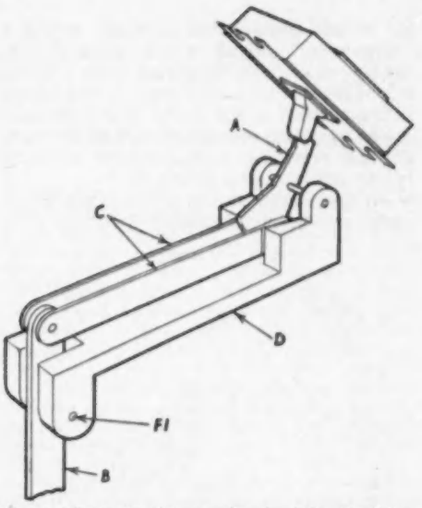


Fig. 2—Mechanism for operating the dolly of switches under test

The switches are loaded by the operator into a channel magazine, from which they are fed by a weight and pulley system into the testing position in the jig. Once loaded, the jig continues to test, without further attention, until the magazine, which holds thirty-two switches, is empty. A further batch of switches can be loaded into the magazine while the previous batch is being tested.

The basic element in the static switching equipment used to apply the four sequential tests to the " Clipper " switches, and to sort the failures into the appropriate bins, is the cold cathode triode tube. This is a small discharge tube containing a neon-argon mixture at low pressure and has three electrodes : anode, cathode and trigger. A positive voltage applied to the trigger with respect to the cathode causes a glow discharge between them, which initiates, in the presence of a positive anode-to-cathode potential, a glow discharge between anode and cathode. This discharge will continue in the absence of any potential on the trigger electrode until the anode volts are considerably reduced.

In the present application it is arranged, by means of rectifier gating circuits, that the presence or absence of signals on intermediate tubes controls the passage of signals through the circuit. A basic circuit is used (described in our March 27, 1959, issue, page 486) in which groups of tubes are made mutually self-extinguishing. Referring to Fig. 4, this means that only one tube in any one of the vertical groups can fire at a time. If another tube in the same vertical group is triggered into conducting, then any other tube which was formerly conducting in that group is automatically extinguished.

The operational cycle is started by means of a reset signal, obtained by the absence of any switch in the jig, which triggers tube 1/1. When a switch comes into position, tube 1/2 is triggered, thus resetting the whole of the logic circuit by triggering tubes 2/1 to 8/1 inclusive. All these tubes remain conducting until extinguished by the firing of any tube in line below. This causes the flap covering

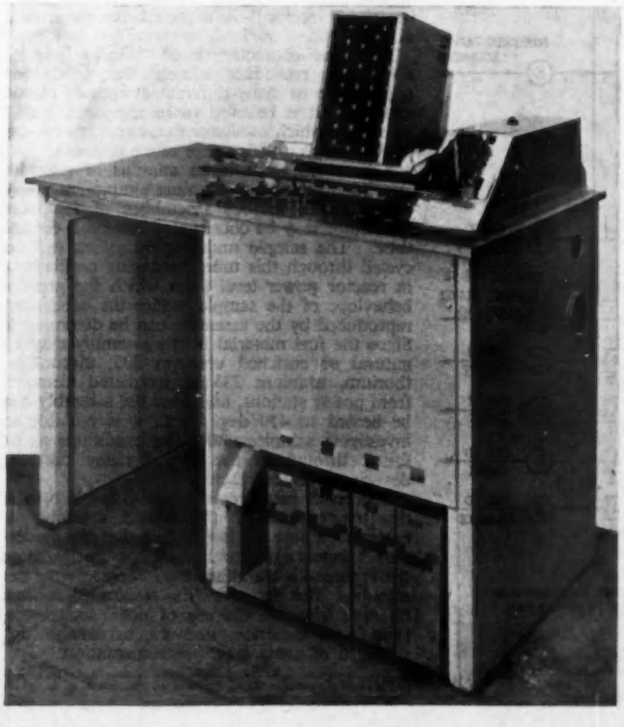


Fig. 1—Switch testing jig, showing the four reject bins and chute for delivery of switches which meet all test requirements

the switch being tested to close, giving a "flap-down" signal which initiates the testing sequence by triggering tubes 1/3 and 8/2. (The circuit is such that the flap closes in the absence of any signal from tube 6/3.)

The operating sequences for the four types of fault previously mentioned are indicated below (references are to Fig. 4).

An open-circuit switch.—The switch-closed signal will never be present, hence tube 1/4 cannot fire. This causes tube 5/2 to be triggered after a time delay, thus triggering tubes 6/3 (the eject solenoid, which opens the flap covering the switch) and 8/3 (the open-circuit trap). Ejection resets the jig and logic circuits ready for the next switch.

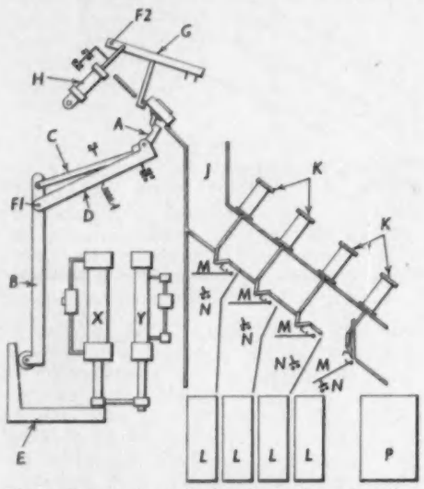


Fig. 3—Pneumatic mechanism for testing and sorting the switches

A break-early switch.—In this case the switch-closed signal is present and tube 1/4 is triggered, thus removing the output signal from tube 1/3 and preventing tube 5/2 from firing. When tube 1/4 fires, it operates the forward travel solenoid via tube 7/2. (The forward travel solenoid controls the valve of the piston which actuates the dolly of the switch being tested). This signal to the solenoid is of short duration because the output from tube 7/2 also triggers tube 7/1 after a short delay, which thus causes tube 7/2 to extinguish. To prevent tube 7/2 from being continuously triggered by tube 1/4, it is arranged that tube 1/5 should fire immediately after tube 1/4 which results in the extinction of tube 1/4.

If the switch breaks early when its dolly is being moved, then the "switch-closed" and 3 deg. limit signals will not be present simultaneously and tube 3/2 cannot fire. Tube 1/6 is triggered when the 3 deg. limit signal arrives and after a time delay, tube 1/7 fires, followed immediately by tubes 1/8 and 4/2. This operates the eject solenoid (6/3) and the reject "break-early" trap (8/4).

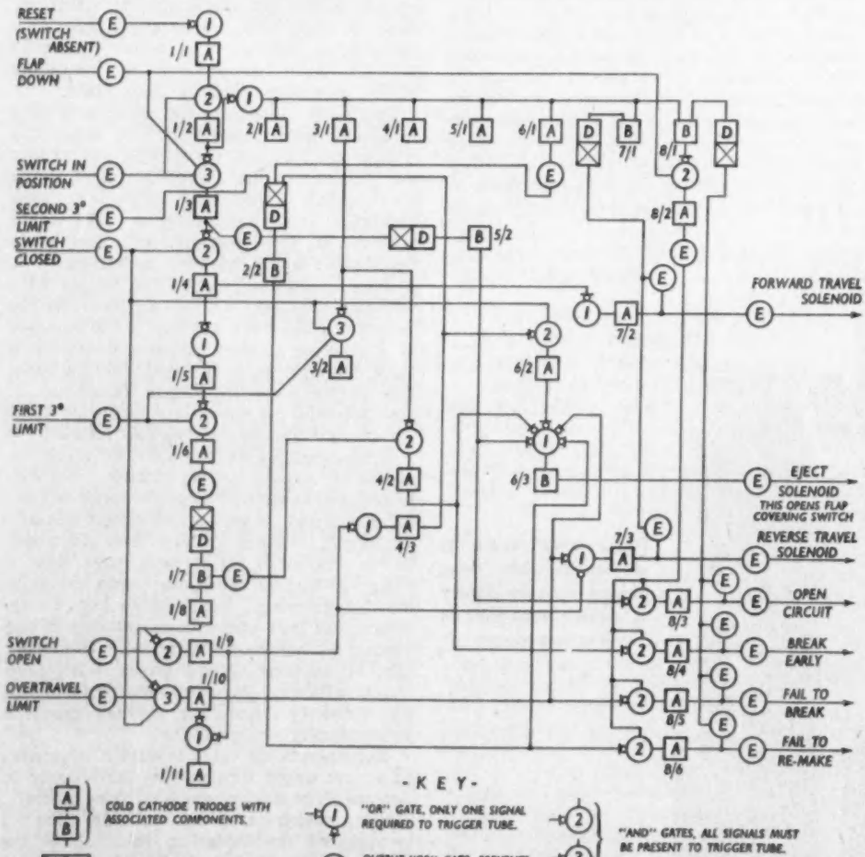
Switch Fails to Break.—In this case the "switch-closed" and 3 deg. limit signals will be present simultaneously and hence tube 3/2 will fire. This prevents tube 4/2 from operating when tube 1/7 fires owing to the lack of a second signal (from 3/1) to its input. Tubes 1/6, 1/7, and 1/8 are triggered in succession as before. If the switch fails to open, then the "switch-closed" signal is sustained and the forward travel mechanism continues to move until the overtravel limit switch closes.

This causes tube 1/10 to be triggered and hence the eject (6/3) and fail-to-break trap (8/5). Tube 1/10 has an output to tube 7/3 which causes the reverse travel solenoid to operate. A signal from tube 7/3 via a time delay to tube 7/1 causes the extinction of tube 7/3 and results in a signal of short duration to the reverse travel solenoid. A further signal from tube 1/10 triggers tube 1/11 and extinguishes itself in doing so, thereby preventing a reverse travel signal.

Switch Fails to Re-make.—In this case the "switch-closed" signal will be replaced by a "switch-open" signal when the circuit is broken. This triggers tube 1/9 and hence tubes 4/3 and 7/3 (reverse travel solenoid). Tube 4/3 supplies signals to tubes 6/2 and 2/2, which will enable them to be triggered when additional signals are present. If the switch does not reclose, then when the second 3 deg. limit switch operates, tube 2/2 will fire after a time delay. This in turn triggers the eject solenoid (6/3) and the "fail-to-re-make" trap (8/6). Tube 1/9 also triggers tube 1/11 which prevents a reverse travel signal from being sustained by removing the output signal from tube 1/9.

In the case of a satisfactory component, the "switch-closed" signal will re-appear before tube 2/2 is fired owing to the time delay in its circuit. This triggers tube 6/2 and hence prevents tube 2/2 from being triggered by removing the signal from tube 6/1. The tube 6/2 also triggers the eject solenoid (6/3) and the switch is ejected down the chute into the "good switch" bin.

For all reject switches, the jig itself closes the reject flap and automatically counts the switches directed to each bin.


RESET (SWITCH ABSENT)
FLAP DOWN
SWITCH IN POSITION
SECOND 3° LIMIT SWITCH CLOSED
FIRST 3° LIMIT
SWITCH OPEN
OVERTRAVEL LIMIT
FORWARD TRAVEL SOLENOID
EJECT SOLENOID THIS OPENS FLAP COVERING SWITCH
REVERSE TRAVEL SOLENOID
OPEN CIRCUIT
BREAK EARLY
FAIL TO BREAK
FAIL TO RE-MAKE
- K E Y -
COLD CATHODE TRIODES WITH ASSOCIATED COMPONENTS.
TIME DELAY UNIT.
"OR" GATE, ONLY ONE SIGNAL REQUIRED TO TRIGGER TUBE.
OUTPUT "OR" GATE, PREVENTS SIGNALS FEEDING BACK.
"AND" GATES, ALL SIGNALS MUST BE PRESENT TO TRIGGER TUBE.

Forward and reverse travel solenoids control the valves of the switch dolly actuating mechanism
Tubes in vertical lines are mutually self-extinguishing, i.e. only one tube in a vertical column can fire at any one time

Fig. 4—Basic arrangement of static control circuits using cold cathode tubes

"Hector" Research Reactor

THE United Kingdom Atomic Energy Authority has signed a construction contract with Fairey Engineering, Ltd., and a control gear design contract with H. M. Hobson, Ltd., in connection with a new zero-energy oscillator reactor which is to be built at the Atomic Energy Establishment, Winfrith. The reactor, which will be called "Hector,"* has been designed expressly to facilitate the use of the "Pile Oscillator" technique for evaluating the nuclear behaviour of fuels, moderators, and structural materials in reactors. This technique, which utilises small samples, has been highly developed by the U.K.A.E.A. to further the reactor physics aspects of power reactor development. "Hector" is expected to go critical during 1962.

A unique characteristic of "Hector" is its ability to reproduce closely the conditions appropriate to many different designs of power reactors. It is believed to be the world's first reactor in which oscillator measurements can be made in such a wide range of conditions.

The reactor core is an annulus of graphite and highly-enriched uranium/aluminium alloy within which various assemblies of fuel and moderator may be constructed around a central tube. The sample under investigation will be cycled through this tube, producing oscillations in reactor power level from which the nuclear behaviour of the sample, under the conditions reproduced by the assembly can be determined. Since the fuel material in the assembly may be natural or enriched uranium 235, plutonium, thorium, uranium 233 or irradiated elements from power stations, and since the assembly can be heated to 450 deg. Cent., it is possible to investigate samples under the conditions to be found throughout the life of many different designs of power reactors.

Successful measurements are possible only if the temperature of the heated assembly is extremely stable. It is desirable that the moderator temperature should not change by more than three-thousandths of 1 deg. Cent. per minute. The design of the reactor to achieve this has involved the use of novel techniques, specialised materials and an extremely high standard of control and instrumentation.

* Heated Experimental C (carbon in the form of graphite) Thermal Oscillator Reactor.

SHORTER REPORTS

Fire Research, 1959

THE reports for 1959 of the Fire Research Board and the Director of Fire Research have now been published : H.M. Stationery Office, price 5s. The study of the causes of fires shows that electric cookers are three times as likely to start fires as gas cookers. However, even electric heaters cause only about half as many fires in buildings as do wires and cables. Including fires in all buildings, not only dwellings, those due to electric equipment were closely twice as many as those attributed to matches (children with).

The various flame-retardant treatments for materials are inherently subject to change in effectiveness with time ; no method of accelerating ageing is accepted, and hence information on these effects is being acquired only slowly. Different paints have been tested over a four-year period on fibre board and plywood and proved generally stable, but a silicate paint deteriorated from Class 1 to Class 4 and a cement-based paint improved from Class 3 to Class 1. In the case of translucent polyester roof panels, exposure to the weather may affect the flame-retardant properties, and so although these roof lights may enjoy the highest designation of resistance to external fire, they are restricted to isolated areas in a non-combustible roof.

There is quoted a report from the Director of the Safety in Mines Research Establishment on the hazards of dust explosions ; among the dusts placed in the most dangerous classification were dried blood, powdered slippery elm, a synthetic sealing wax, and dust from a tramcar control unit. A study at model scale of the burning of oil floating on water showed that only part of the oil in a film 2mm thick would burn, while a film 1mm thick was difficult to ignite in a wind of 4-8 m.p.h. Flame propagates across these thin films at about ½ m.p.h.

Slough Occupational Hygiene Service

ESTABLISHED in 1947 under the sponsorship of the Nuffield Foundation, the Nuffield Provincial Hospitals Trust and Slough Estates Limited, the Slough Industrial Health Service has grown to serve an industrial population of over 20,000 and to provide a comprehensive medical service on which others in different parts of the country have been modelled. The organisation of the service was the subject of an article in THE ENGINEER for September 18, 1955 (page 411).

An important part of the service, started about two years after the medical units came into operation, is the occupational hygiene section. This was developed as a result of requests from member firms for advice on matters which were not strictly the concern of the medical staff, but were more the province of the engineer. Members asked, for example, for advice on working conditions involving such questions as temperature, humidity and ventilation of workplaces, lighting, noise, exposure to dust, toxic gases and radio-active material. It was therefore decided to recruit a team of specialists who would be able to investigate specific problems and to formulate solutions based on their findings.

In its early days the Slough occupational hygiene team was quartered at the London School of Hygiene and Tropical Medicine. It was led by a physician, and an engineer was engaged and given special training, which, in the absence of facilities in Britain, had to be done in the U.S.A. In due course the team was moved to new headquarters at Slough, where fully equipped laboratories have been provided, and the facilities and staff have been augmented as a result of experience gained. The staff now consists of a physician, an occupational hygiene engineer, a chemist, a noise technician, laboratory assistant and secretary. A chemical laboratory provides facilities for general chemical analysis ; noise and dust investigation are catered for in separate laboratories.

At first the work of the occupational hygiene team was confined to investigations for Slough Industrial Health Service members, but it has now been expanded to undertake outside consulting work as well. Investigation work for member firms continues, and the team is also engaged on a research project under the auspices of the Medical Research Council. The problems submitted to the team are very varied. Some originate because an existing process may have a known, or suspected, hazard. Others are submitted to the team by manufacturers who are proposing to use a process or a material which is new to them. It is obviously better for all concerned if the team s advice is sought when a project is in the design stage; trouble, expense, or both can often be avoided by this means. Such a course was adopted by a paint firm, which developed an anti-corrosive coating for steel plate to be applied before welding. Two questions arose. Would the product have any detrimental effect on the welding, and would it produce fumes harmful to the welders ? The first of these questions was outside the scope of the Slough team, and the answer was sought elsewhere, but the second was submitted for investigation. Many environmental tests were carried out, under simulated working conditions, and analyses showed, *inter alia* that there could be considerable danger to health due to the presence of acrolein. From these findings the team made recommendations for ventilation of working places, and the manufacturer was able to market a product which, if used under proper conditions, was safe in all respects.

By its technical composition the team is able to study all the aspects—clinical, chemical and mechanical—of a problem and, if necessary, to carry out tests to show that its recommendations are effective. The results of an investigation are submitted to an engineer in the form of a statement of the nature and extent of the hazard discovered, accompanied by recommendations for its elimination. The team does not undertake the detailed design of the mechanical or other equipment it recommends, but submits its suggestions in a form which is readily understood by engineers and manufacturers of suitable products. Its work is entirely confidential.

Flight Deck Communications System

A FLIGHT deck communications system designed to permit voice communication between a flight deck control centre and flight deck crews has been developed by the Telecommunications Division of The Plessey Company, Ltd., Ilford, Essex, on behalf of and in conjunction with the Admiralty. Normally, direct voice communication on the flight deck is impossible due to the level of aircraft noise and to the ear protectors worn by crew members. The new system enables the controller to transmit orders over a broadcast channel at audio frequencies. Signals are fed into a magnetic coupling loop encircling the flight deck of the aircraft carrier. Individual crew members carry a receiver that picks up the audio signals, amplifies and feeds them to an earphone built in the ear-protector.

Key members of flight-deck crews are able to talk back to the control centre by means of a v.h.f. radio transmitter which is carried clipped to the receiver. This fully-transistorised miniature portable equipment is battery-operated and protected by a nylon cover. It may be carried in the user's pocket, allowing full freedom of action.

Crystal control provides a pre-set frequency for the v.h.f. transmitter. The audio output of the receiver is kept constant by automatic gain control, thus dispensing with operating controls on the portable equipment. The flying control centre equipment is housed in a standard Admiralty cabinet, and is operated from the ship's electrical supply system.

At the flying control centre the audio signal for the broadcast channel is selected from one of three input points : a local microphone, a remote microphone, or the talk-back channel. After amplification by a microphone pre-amplifier, the audio signals are mixed with a signal which is used for A.G.C. and the combined signal is fed to the push-pull power amplifier, consisting of an amplifying stage, cathode-follower drivers, and Class B output stage. An output transformer matches the low impedance of the magnetic loop which encircles the " island " and the flight-deck.

The portable receiver issued to each member of the flight-deck crew contains a pick-up coil consisting of a potted ferrite inductor which receives the combined audio-frequency and A.G.C. signals from the broadcast loop. After amplification the audio signal is separated in a low-pass filter and applied to the output stage which drives the headset. The A.G.C. signal is selected in a tuned amplifier stage, rectified and applied to the first amplifying stage to control its gain thus keeping the audio output substantially constant.

Talk-back from the crew to control is effected by means of a v.h.f. radio link. Key members of the crew each carry a transistorised transmitter, which is mechanically joined to the broadcast channel receiver to form a dual unit. A crystal oscillator feeds a frequency-trebler which provides the r.f. signal for the transmitting stage. The microphone input is amplified by two common emitter stages and fed *via* an emitter-follower to modulate the output of the transmitter. The screen of the microphone lead, which is a quarter-wavelength, is used as the transmitting aerial. The transmitter is preset and crystal controlled and no tuning operations are required. For alignment checking, test points are available which are accessible without removing the protective cover.

At the control centre a standard v.h.f. receiver is used and is normally mounted in the same rack as the broadcast transmitter.

[Reply Card No. E4733]

H.F. Induction Heaters

FOUR new Philips h.f. induction heaters are being marketed by Research and Control Instruments, Ltd., Instrument House, 207 Kings Cross Road, London, W.C.1. All models, with ratings of 6, 12, 18 and 30kW are adapted for conversion by a change of standardised units, to high, medium or low impedance and high, medium and low kVA output. Controls and power output are mounted on adjacent sides of the cabinet, keeping the work station clear. All controls and meters are at comfortable working height on a standard panel which is hinged for easy servicing. All panel-mounted accessories are interchangeable. Joints are hermetically sealed and internal air-cooling arrangements are incorporated, making the heaters substantially independent of local atmospheric and temperature conditions.

Among the applications for which the new heaters are suitable are soft and silver soldering, brazing, tempering, annealing, through surface and localised hardening, forging, melting, gear and shaft hardening, zone refining, crystal pulling, graphite heating, tool tipping, sintering, hot pressing, valve electrode outgassing, and shrinking. A number of accessories and services are available, such as process timers, remote control terminals, water flow switches, and an electro-mechanical servo for load matching or to operate from outside parameters. Among facilities which can be supplied to individual requirements are circuits for programming and metering.

[Reply Card No. E4734]

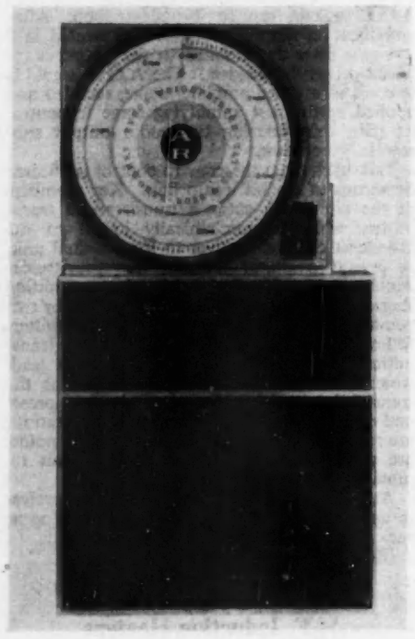
SHORTER REPORTS *(Continued)*

Weight Recorder

A NEW weight recording instrument for use with scales and weighbridges and known as the "Weighprinter" indicator has been developed by Ashworth Ross & Co. Ltd., Scout Hill, Dewsbury, Yorks. This instrument, to be seen in our illustration, records weights on an external ticket and an internal paper roll. It is available in capacities ranging from 5 cwt to 100 tons.

A "stop-fraud" mechanism incorporated consists of a photo-electric scanning device which isolates the printing drive motor until the scale is in equilibrium and makes it impossible for the printed record to be made until the scale pointer has come to rest. No manual external controls are fitted and push-button operated independent motors actuate the capacity range selectors and the printing cycle. If required, both of these functions can be remotely controlled and automatic weighing and printing cycles interlocked with other equipment. An electric-mechanical transposing unit can be combined with the decimal printing to give a digitised output in the form of a five-channel punched tape. Alternatively the unit can be arranged so that the scale will directly control an electric typewriter or adding machine.

[Reply Card No. E4741]



Weight indicating and recording instrument for scales and weighbridges.

Tractor Hitch

A NEW device, known as the "Multipull" hitch, designed to provide a constant transfer of weight from a trailed implement or a four-wheeled trailer to the rear wheels of the tractor, has been introduced by Massey-Ferguson, Ltd., for use with its "65" tractor. The hitch, which is easily attached to the tractor's three-point linkage, may be used in conjunction with either a swinging drawbar or with an automatic pick-up hook. In the illustration we reproduce it can be seen that the normal linkage for the pick-up hitch has been replaced by two chains. A third chain is taken around the drawbar of the implement or trailer and is attached to the hitch by a pulley running on a rail, thereby allowing short turns to be made.

Hitch for the transfer of weight to the rear wheels of the "65" tractor

When being used with a mounted implement, such as a plough, the top link on a Massey-Ferguson tractor works in compression to operate the hydraulic mechanism automatically, but with a "Multipull" hitch fitted, the top link works in tension, so that as the tractor pitches over uneven ground, the varying tension forces transmitted through the top link cause the control valve to re-adjust automatically the position of the two lower links, thus maintaining a steady lifting force on the drawbar of the implement or trailer. In this manner a constant transfer of weight is maintained to the rear wheels of the tractor, giving them a greatly increased "grip" and better braking power.

Operation of the draft control lever causes a lifting force to be exerted by the lower links, which, when attempting to take up the weight of the trailer, in turn, forces the rear wheels of the tractor downwards. Weight from the front end of the tractor is also transferred to the rear wheels as a result of this action. In order to counteract the effect on stability and steering of so much weight being transferred from the front to the rear of the tractor, Massey-Ferguson has introduced a front mounted weight-frame which, being mounted further forward than wheel weights, is claimed to be more effective. A maximum of eight 60 lb weights can be fitted to the frame which itself weighs 45 lb, giving a total additional weight to the front of the tractor of 525 lb. Each weight is located by the tightening of a nut and may be easily removed when not required.

An initial supply of the new hitches, which were originally developed and patented for use with implements such as a gang roller or heavy harrow by Massey-Ferguson's Swedish distributer, Aktiebolaget Farming, has been imported from Sweden, but hitches made in Massey-Ferguson's Kilmarnock factory will become progressively available.

[Reply Card No. E4742]

High Angle Belt Conveyor

A HIGH ANGLE belt conveyor system, for use in deep quarries and open-cast coal-mines has been developed by a German company and its manufacturing rights in this country acquired by Richard Sutcliffe, Ltd., Horbury, Wakefield. The basic principle of these conveyors can be seen in the accompanying illustration — an endless belt of flexible chain matting is laid over the load on the conveyor belt to prevent the materials from rolling or slipping. The weight of the mat used depends upon the nature of the material and on the conveying angle involved.

The chain-mat belt runs at the same speed as the main conveyor belt but is carried independently by a supporting belt driven from a single drum drive unit mounted on the loading frame. It is stated that materials need not be sorted before being loaded onto the conveyor belt as the flexibility of chain mat enables large material lumps to be covered and prevents the escape of adjacent smaller pieces of material. In addition to covering the material and increasing the frictional hold of the material on the conveyor belt by its weight, the chain mat is stated to provide about 40 per cent of the required total conveying power.

When the conveyor belt is empty the mat lies on and rotates with it and incomplete conveyor belt loading and stopping have no effect upon the ability of the chain belt to hold the charge without slip.

[Reply Card No. E4743]

High angle belt conveyor with complementary chain mat belt to prevent materials slipping on steep gradients

London Transport Chesham Branch Electrified

THE last passenger steam train on the Chesham branch of the Metropolitan line of London Transport left Chalfont and Latimer station at 12.3 a.m. on Monday, September 12, and arrived at Chesham, the terminus of the 3·9-mile, single-track branch at 12.11 a.m. Normal passenger services were taken over at 6.12 a.m. on September 12 by an electric shuttle train of two motor cars of the Metropolitan line compartment type "T" stock, with an intermediate trailer car. Electrification has made possible the withdrawal of one of the few remaining steam "push-pull" sets and some of the oldest standard-gauge passenger coaches in service in the country.

Opened in 1889, the Chesham branch was part of the Metropolitan Railway's extension northwestwards from Rickmansworth to Amersham and Aylesbury authorised in 1885. As the main line from Chalfont and Latimer station (Chalfont Road as it was called until 1915) was not completed until 1892, Chesham was for more than three years the northern terminus of the Metropolitan line. In 1902 the whole line, from south of Harrow-on-the-Hill northwards came under the control of the Metropolitan and Great Central Joint Committee, the individual companies providing and working the trains. After nationalisation responsibility for the line was transferred to London Transport, but British Railways operate the freight traffic and run passenger trains between Marylebone, Aylesbury and the Midlands.

Electric trains reached Rickmansworth as long ago as 1925, and an extension northwards was planned, only to be stopped by the war. The present electrification of the Chesham branch is part of a £9,000,000 improvement scheme which replaces some of the steam trains over 10 miles of track between Rickmansworth, Chesham and Amersham. When the scheme is completed, in about eighteen months, it will include complete electrification as far as Amersham, the doubling of 6 miles of track between Harrow and a point south of Rickmansworth, extensive rebuilding of stations, and resignalling.

Some 32 miles of conductor rail have been laid, and two new substations have been built at Chorley Wood station and north of Chalfont station. Each substation has an installed capacity of 3000kW, using mercury-arc rectifiers. Current is fed from Greenwich Power Station via Neasden Power Station at 11,000V, 50 c/s to the new substations where it is transformed and rectified to 600V d.c., the standard London Transport traction voltage.

Vertical Spindle Grinding Machine

PARTICULARS of a new machine and technique for grinding flat surfaces on components at high speeds to close tolerances developed in the United States by the Mattison Machine Works have been received from that company's agents, Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11. On this machine, to be seen in our illustration, the components are mounted on fixtures on an indexing table and carried in turn to the grinding station. The grinding wheel spindle is mounted in a planetary head which moves it in an orbit around the centre point of the work as the grinding operation proceeds. The principle followed is generally similar to conventional surface grinding practice in a vertical spindle machine, but instead of the workpiece being rotated it remains stationary and the grinding wheel axis rotates round its centre point at about 60 r.p.m.

It is claimed that the new method has a number of advantages in that as the component is held stationary in its fixture it is accurately positioned and is easy to load, transfer and unload. Further, simple fixtures incorporating light means of clamping for thin work can be used on the indexing table, whilst continuous grinding increases machine utilisation and separate drives do not have to be built into the table to rotate the components. An air-gauging unit, to be seen over the ground component on the left-hand side of the table, actuates an independent automatic feed device controlling size.

Vertical spindle grinding machine on which the grinding wheel moves in an orbit round workpieces held stationary in fixtures on the indexing table

The planetary wheelhead of the machine can be fitted with one or two spindles, depending upon production requirements. Two driving motors are used, one driving the spindle itself, and the second revolving the spindle assembly to impart the orbiting movement. It is stated that this design of machine has been used to grind pump piston covers to a flatness tolerance of 0·0005in and remove up to 0·004in of stock at a production rate of 140 parts an hour.

[Reply Card No. E4752]

"No-Break" Supply for Norwegian Telecommunication Services

WE illustrate a large engine-driven "no-break" alternator installed and commissioned in Norway to ensure continuity of electrical supply to navigation and telecommunication services. The prime mover is a Paxman 8 RPH engine, having a British Standard site rating of 366 b.h.p. at 1500 r.p.m. The driven machinery comprises a 200kW, 220V/127V, three-phase 50 c/s alternator, flexibly coupled to an asynchronous motor, which in turn is flexibly coupled to a heavy flywheel carried on a shaft supported by taper roller bearing pedestals.

Connection or disconnection between the engine and the driven units is effected through an electrical induction clutch coupling which is energised from the engine starter batteries. A pedestal bearing supports the weight of the coupling, the drive from the engine being taken to the induction coupling through a flexible rubber coupling specially designed to eliminate axial forces. The whole assembly is mounted on a baseplate of fabricated steel.

A panel carrying the automatic starting, control and distribution gear is provided, also equipment to give visual and audible indication of the operation of the safety features fitted to the engine.

The standard Paxman eight-cylinder engine is equipped with accessories which include safety devices for low oil pressure, high oil temperature, high water temperature, low water pressure, overspeed and underspeed. Jacket water is cooled through a remote-mounted radiator, and the oil cooler is circulated with cooling water from the engine jacket cooling circuit. Jacket water temperatures are regulated thermostatically and thermostatically controlled immersion heaters are fitted to the engine water jackets and lubricating oil sump.

When the engine is not running, the engine lubrication system is periodically primed through the medium of an electrically-driven pump which operates automatically on a time-cycle basis. Push-button control is provided to enable the pump to be operated independently if desired for the purpose of evacuating the lubricating oil from the engine sump.

The alternator provides power for a group of load circuits requiring uninterrupted supply. In the "mains healthy" condition, the mains power drives the alternator and flywheel via the asynchronous motor, the engine being stopped and the induction coupling not energised.

In the event of mains voltage or frequency falling below a stipulated level, or a complete failure of mains supply, the induction coupling is automatically energised to engage, thus causing the inertia of the already rotating flywheel to turn the engine shaft. Simultaneously, the engine starter motor is energised to engage and the engine fires. During the transitional period while the engine is accelerating to full speed, the output frequency is maintained to within 4 per cent of the normal 50 c/s by the stored energy in the flywheel and the output voltage thus remains within 10 to 12 per cent of its nominal value.

On restoration of mains supply following a failure, the electric motor again takes up the drive and the induction coupling is automatically de-energised, allowing the engine to be stopped through the action of a solenoid-operated device.

Initial starting of the plant from rest is achieved by starting up the engine from its integral 24V starter motor, engaging the clutch coupling, and accelerating the engine to bring up the flywheel to the running speed of 1500 r.p.m. When this speed is reached mains power is switched to the motor which then takes over the drive, the coupling is disengaged, and the engine is shut down.

The overall dimensions of the complete set are : length, 22ft 3in ; width, 6ft 3in ; height, 6ft 6in ; approximate net weight, 17 tons. The flywheel, which is of cast steel and is both statically and dynamically balanced, weighs 5·8 tons.

For emergency use in the same power house a further 200kW set also powered by an 8 RPH engine is installed. (British Standard site rating, 366 b.h.p. at 1500 r.p.m.) This is a conventional set designed for manual starting through a 24V electric starter motor and will only be needed in emergency or when the "no-break" set is being overhauled. Both sets have similar cooling systems. The two sets are arranged for parallel operation.

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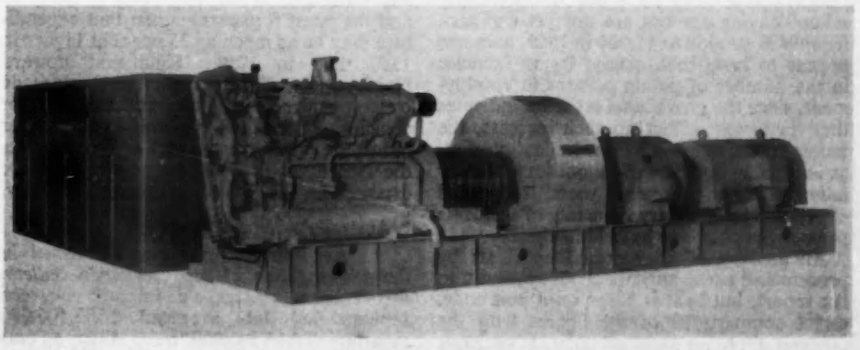


366 b.h.p. "no-break" generating set installed in Norway to ensure continuity of electricity supply for navigation and telecommunication services. It consists of a three-phase, 200kW alternator flexibly coupled to an asynchronous motor, a flywheel and a Paxman 8 RPH engine. The control cubicle is also shown

INDUSTRIAL NEWS

Mission to the Argentine and Chile

The Council of British Manufacturers of Petroleum Equipment has issued its *Report of the Exploratory Mission to the Argentine and Chile*, price 12s. 6d., which recalls that the terms of reference of the mission were to introduce the potential of the British petroleum equipment industry, to investigate opportunities and to discuss credit facilities. The report touches upon the political and economic background in Argentina and notes the position of the oil producing areas and the organisation of the Yacimientos Petroliferos Fiscales (Y.P.F.). Future policy of Y.P.F. is outlined together with a list of capital projects being planned. Operation and capacity of the oil industry in Chile are stated and also the credit terms expected. In a general summary the report stresses that the operative word is " credit " and that there will be a demand for capital equipment over the next ten years so that eventually it will become more difficult to export manufactured goods. Certain firm recommendations are made in the report and appendices list the oil companies visited and the individuals met by the mission. Other information included in the report concerns items of incidental intelligence, touching upon the growing availability of natural gas, loans, hours of work, demand for consumer goods, rate of growth, &c. Drilling contractors' activities are recorded and a final section gives examples of credit terms reported.

The Factory Inspector's Report

The Annual Report of the Chief Inspector of Factories 1959, has been published this week (H.M. Stationery Office, price 7s.). Although fatal accidents in industry in 1959 fell to the lowest figure reported this century, there was a disappointing reversal in the downward trend of the previous three years in the total number of accidents. The total number of accidents reported rose from 167,697 in 1958 to 174,071 last year, whilst fatal accidents declined in the same period from 665 to 598. The report points out that the level of industrial production rose considerably during 1959 and suggests that the increase in accidents may be partially explained by the increase in the number of people employed. The disturbing increase in the number of accidents to young persons, that is those who have reached statutory school-leaving age but are not yet eighteen, from 9838 in 1958 to 11,001 in 1959, does not appear to have been caused by an increase in the number of young persons in employment, since the provisional estimate indicates that there was in fact no such increase, the report states, but it is a clear indication that, as increasing numbers of school leavers enter industry in the coming years, redoubled efforts will be necessary if the rate of accidents to young people is to be held in check.

An analysis of all reported accidents by process and cause appears as an appendix to the report, but as it is based on a new code, direct comparisons of the figures with the analysis of the causes of accidents in previous years would be of little validity. The largest single category of accidents during the year was " handling goods." which accounted for 26·2 per cent of the reported factory accidents. Accidents from this cause occurred quite generally throughout industry, the report says, being slightly more frequent proportionately in engineering, metal producing and food processes. Accidents caused by falls of persons represented 15·1 per cent of the total of accidents in factories, and also accounted for ninety-one fatal accidents. There were 31,288 accidents classified as caused by machinery, of which 125 were fatal ; 28,530 of these accidents, including eighty-seven fatal accidents, were in factories the report adds.

Accidents on building operations and works of engineering construction are analysed in the report in considerably more detail than in previous years. There were 15,410 accidents reported from building operations, 169 of them fatal. Works of engineering construction resulted in 2875 reported accidents, forty-eight of these being fatal. The total number of electrical accidents during 1959 was 738.

At the end of the year, the report states, the total number of registered factories was 222,117 compared with 223,085 at the end of 1958. An analysis made during March showed that approximately one-quarter of workers in factories were in factories employing more than 1000 people, but only four factories in every 1000 were of this size. Factories employing fewer than ten people represented more than two-thirds of the total, although the number of employees was only one-thirteenth of the number of factory workers.

Capital Expenditure

Estimates made from forecasts sent to the Board of Trade by a sample of companies during the summer indicate, the Board says, that fixed capital expenditure by private industry and business in 1960 will be about 20 per cent above the level of 1959, instead of about 16 per cent more as estimated at the beginning of this year. This slight increase is attributable wholly to the revised estimates provided by manufacturing industry.

Manufacturing industry's capital expenditure, according to companies' forecasts made towards the end of last year, was expected to be about 14 per cent higher in 1960 than in 1959, but forecasts received during the summer indicate, the Board suggests, that many companies are now expecting to spend more on capital account in 1960 than they had envisaged at the beginning of the year and the latest forecasts suggest that expenditure may be as much as 25 per cent higher in 1960 than in 1959. Significant upward revisions to earlier forecasts have been made by companies in the iron and steel, motor vehicles, paper and printing and rubber industries. The greater part of the increase, the Board of Trade adds, continues to be expected on the side of plant and machinery.

Australia's Import Trade

According to a survey published in the current issue of the Treasury's *Bulletin for Industry* Australia's imports between January and July averaged £A83,500,000 monthly—£A16,500,000 more than a year earlier and £A13,500,000 more than in the financial year 1954/55. This expansion in our second largest market is a clear challenge, the survey suggests, to the enterprise of United Kingdom exporters.

Last February the Australian Government abolished licensing for all except about a tenth of the country's imports and increased the quotas which remained by 20 per cent, but it is an open question what long-term effect " thorough-going liberalisation " will have on the size and composition of Australia's imports. In particular, the survey warns, it cannot be assumed that products supplied by the United Kingdom will benefit fully from the general expansion. Between January and July United Kingdom exports to Australia were 18 per cent larger than a year earlier, whilst total Australian imports were 25 per cent larger.

Although the United Kingdom is still Australia's largest supplier, the survey recalls that her average monthly exports dropped from £23,200,000 in 1954 to £18,600,000 in 1959. In the first seven months of this year they recovered to £21,500,000. The United Kingdom's share of the total import market fell from 45 per cent in 1954/55 to 36 per cent in 1959/60. North American, German and Japanese suppliers have gained ground, the Treasury says.

Some of Australia's main imports of interest to United Kingdom suppliers, the survey says, are non-electric machinery, which between July 1958 and December 1959 averaged £A9,900,000 monthly ; motor vehicles and parts £A5,600,000 ; other metal manufactures and metals £A6,400,000 ; electric machinery £A3,200,000 ; and chemicals, drugs and fertilisers £A3,500,000. Imports of chemicals, machinery and manufactured paper have grown substantially since 1954/55, whilst imports of textiles, motor vehicles and parts, and other metal manufactures and metals have dropped sharply. In every case, the survey points out, imports from the United Kingdom have grown less or dropped more than total imports.

From July 1947 to June 1959 United Kingdom investment in companies in Australia, including net income retained in Australia by United Kingdom firms, totalled over £A580,000,000—62 per cent of all overseas investment in companies in Australia. The figure for the United States and Canada, the survey records, was nearly £A260,000,000 or 27½ per cent.

Employment

During July, the Ministry of Labour says, the number of people in civil employment is estimated to have increased by 69,000 to 23,662,000. The largest increases recorded were 27,000 in the financial, professional, scientific and miscellaneous services, 23,000 in the distributive trades and 18,000 in catering, hotels, &c. The number of people employed in manufacturing industries increased by 14,000 to 8,848,000. On the other hand, the number of people employed in the construction industry fell by 8000 to 1,533,000, and in mining and quarrying the labour force declined by 5000 during July, the number employed being 760,000. In the week ended July 30, the Ministry says, the number of operatives working short time in manufacturing industries was 20,900 which was 8800 fewer than at the end of June.

PERSONAL AND BUSINESS

Appointments

MR. STANLEY K. WHEATLEY has been appointed a director of the Sheffield Wire Rope Company, Ltd.

BRAY CONSTRUCTION EQUIPMENT, Ltd., has announced the appointment of Mr. W. Muir as London manager.

DR. T. W. STRAKER has been appointed deputy manager of the radar division of Marconi's Wireless Telegraph Company, Ltd.

MR. A. MARCHAM, M.I.C.E., has been appointed director and general manager of the Concrete Development Company, Ltd.

MR. S. J. BARNES, director and general manager of Clayton Dewandre Company, Ltd., has been appointed managing director.

DR. R. H. GRIFFITH, Director of Research at the Gas Council's London Research Station, retired from his post at the end of August.

THE MINISTRY OF AVIATION states that Mr. A. C. Ping has been re-appointed as a member of the board of British European Airways for a further two years.

DR. RICHARD V. WATERHOUSE has been appointed managing director of Acoustical Investigation and Research Organisation, Ltd., a member of the Hall-Thermotank Group.

MR. E. H. S. VAN SOMEREN has joined the British Welding Research Association as a principal scientific officer and is to work on fundamental studies on the physics of the welding arc by optical observations.

MR. A. S. PAICE has been appointed export co-ordinator for Square D, Ltd., and will be based at the company's Swindon headquarters. He has been succeeded as Midlands area manager by Mr. R. Ritchie.

MR. J. R. MOORE, manager of the Fisher Governor Company at the Rochester factory of the Elliott-Automation Group, has been appointed assistant general manager of the Elliott Valve Group of Companies.

LIEUT-COLONEL R. B. LAKIN has been appointed a director of Vickers-Armstrongs (Engineers), Ltd., and general manager of the company's North East Works, in succession to Mr. J. R. Kelly who has reached normal retirement age.

THE BRITISH PETROLEUM COMPANY, Ltd., announces the following appointments as directors of subsidiary companies: Mr. John McVean Luard, B.P. Exploration Company, Ltd; Mr. John Moffat, B.P. Refinery (Llandarcy), Ltd., B.P. Refinery (Kent), Ltd., B.P. Refinery (Grangemouth), Ltd.

MR. W. A. ANKERSON has joined the board of Associated Electrical Industries (Woolwich), Ltd., as assistant managing director. He will relinquish his appointment as general manager, A.E.I. home district offices, and will cease to be a director of Associated Electrical Industries Overseas, Ltd.

THE INTERNATIONAL MECHANITE METAL COMPANY, Ltd., announces the reorganisation of its board of directors: Mr. Oliver Smalley has been appointed chairman of the board with Mr. P. Attenborough as managing director. Other directors are Mr. E. M. Currie, Mr. E. W. Harding and Mr. G. Hobman.

METAL INDUSTRIES, Ltd., announces the following appointments: Mr. D. L. Freeman has been made a director of Cox and Danks, Ltd., responsible for the London branch of the company; Mr. B. W. G. Gurney has been appointed managing director of Farmer Brothers (Shifnal) Ltd., Mr. C. G. Abel has been appointed general sales manager of Farmer Brothers.

THE GOODYEAR TYRE AND RUBBER COMPANY (GREAT BRITAIN), Ltd., has announced the appointment of Mr. J. L. Mumby as financial director and secretary in succession to Mr. W. R. Booth, who has returned to the United States as an assistant treasurer of the parent Goodyear Tire and Rubber Company in Akron, Ohio, and treasurer of the subsidiary Goodyear International Corporation.

BRITISH AIRCRAFT CORPORATION, Ltd., announces that all the formalities in taking over a controlling interest in Hunting Aircraft, Ltd., have now been completed. Sir George Edwards and Mr. W. Masterton have been elected to the board and Mr. G. L. Hunting and Mr. R. R. S. Cook have left the board. The composition of the board is now: Sir Percy Hunting, chairman; Sir George Edwards, Hon. F.R.Ae.S., vice-chairman; Mr. C. P. M. Hunting, Mr. L. C. Hunting, Mr. William Masterton, Mr. W. A Summers, F.R.Ae.S., managing director; Mr. K. D. Morgan, secretary and commerical director; Mr. F. W. Buglass, M.I.Prod.E., works director; Mr. F. H. Pollicutt, F.R.Ae.S., technical director.

Business Announcements

UNITED DOMINIONS TRUST, Ltd., is opening a new branch office at 2, Queen Square, Bath, Somerset, (telephone, Bath 5821-2), on September 19.

CAPE BUILDING PRODUCTS, Ltd., Cowley Bridge Works, Uxbridge, Middlesex, states that the telephone number of its head office is now Uxbridge 37111.

RENAULT MACHINE TOOLS (U.K.), Ltd., has opened a new works at Monkmoor Road, Shrewsbury, Shropshire (Telephone, Shrewsbury 52317).

F. J. EDWARDS, Ltd., Edwards House, 359-361, Euston Road, London, N.W.1., states that its London telephone number has been changed to Euston 5000.

THE MINISTRY OF HOUSING AND LOCAL GOVERNMENT has appointed Sir Frederick Armer to hold a public inquiry into proposals for relief roads at Oxford. The inquiry will start on December 1, 1960, and will be held at the Town Hall, Oxford.

PLANNAIR, Ltd., has announced that under the terms of a licence agreement with the Lear-Romec division of Lear Incorporated, Elyria, Ohio, the American company will be able to make the full range of Plannair blowers for use in the U.S.A. and Canada.

THE RUBEROID COMPANY, Ltd., has announced the formation of the Ruberoid Company of Australia Pty, Ltd., in conjunction with the Colonial Sugar Refining Company, Ltd., of Sydney. Ruberoid roofings and bituminous building materials will shortly be available manufactured in Australia from a plant to be erected in an industrial suburb near Melbourne.

BURTONWOOD ENGINEERING COMPANY, Ltd., Warrington, Lancashire, announces that it has entered into an agreement for the selling and distribution of its oil seals in South Africa. J. H. Vivian and Co., Ltd., Johannesburg, is now responsible for stocking and selling all varieties of oil seals made by Burtonwood and used in industrial applications.

THE PERMUTIT COMPANY, Ltd., Permutit House, Gunnersbury Avenue, London, W.4., and the UBS CHEMICAL COMPANY, of Cambridge, Mass, a division of the A. E. Staley Manufacturing Company of Decatur, Ill, have announced a joint venture for production and distribution of "Ubatol" brand polymer emulsions overseas. The synthetic polymer products will be produced at Permutit's chemical works in Glamorgan.

C. SEEGER MASCHINENFABRIK, Stuttgart, has appointed Aldersby Engineers, Ltd., Wolverhampton, as its agent in this country for Seeger malting equipment, including the new "Wanderhaufen" germinating plant system. The agreement embraces the existing Aldersby equipment in such a manner that Aldersby Engineers, Ltd., will be able to undertake a complete malting process installation. Mr. K. W. Leaton, A.M.I.Mech.E., has been appointed by Aldersby as engineer-in-charge responsible for technical advice and installation of the equipment.

THE DELTA METAL COMPANY, Ltd., and YORKSHIRE IMPERIAL METALS, Ltd., announce that arrangements have been made whereby the alloy tube manufacturing business hitherto carried on by Booth and Mapplebeck, Ltd., a member of the Delta Group, will be acquired by Yorkshire Imperial Metals, Ltd., and that Delta will take an interest in the latter company.

Contracts

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, Ltd., in collaboration with VOEST A.G. of Austria, is to undertake the design and supply of a complete L.D./A.C. oxygen steelmaking installation at the Scunthorpe steel works of John Lysaght's Scunthorpe Works, Ltd. The plant, which will include a 1000-ton hot metal mixer, two 50/60-ton converters, cranes and handling machines, waste heat boilers, gas-cleaning plant, buildings and ancillary equipment, is designed initially for the production of 400,000 tons of ingots a year with provision for extension to 800,000 tons a year. The total value of this order exceeds £2,500,000.

WOODALL-DUCKHAM CONSTRUCTION COMPANY, Ltd., 63-77, Brompton Road, London, S.W.3, announces orders for two new coking plants together valued at over £4,000,000. One is for the Ravenscraig Works of Colvilles, Ltd., and includes complete coal and coke handling systems and a by-product recovery plant. The other is for the United Coke and Chemicals Company, Ltd. (a subsidiary of the United Steel Companies, Ltd.), at Ongreave. This contract includes the demolition of a derelict battery as well as the building of a new one of forty-three ovens, with by-products and benzole plants and a gas boosting plant. Both coking plants are due to be in operation by the end of 1962.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has received an order from the British Broadcasting Corporation for a 50kW medium frequency broadcast transmitter for radiating the light programme from Brookmans Park on 247 metres. It will replace a Marconi transmitter installed for the service in 1929. The BD.228 transmitter which is now to be installed is a new design in which the equipment is contained in two free-standing cabinets bolted together, the left-hand cabinet containing the modulator, main high tension rectifier and low-voltage supply and distribution. The right-hand cabinet houses the complete radio-frequency stages except, in this case, the drive, which is being provided by the B.B.C. and is external to the transmitter. The output stage of the transmitter uses a hgih-efficiency circuit patented by the Marconi company which gives the transmitter an overall efficiency of 66 per cent at carrier, 60 per cent at 30 per cent modulation and 62·5 per cent at 100 per cent modulation.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., Transformer Division, has received an order from the Central Electricity Generating Board, Southern Project Group, for high-voltage testing equipment to be installed at the Central Electricity Research Laboratories at Leatherhead. The equipment ordered includes five high-voltage testing transformers, associated voltage regulators and control gear, selenium-iron rectifiers, a smoothing capacitor and an earthing switch. Two of the transformers are outdoor units and can be used individually or in cascade to give outputs of (*a*) 500kV at 1000kVA continuously; (*b*) 500kV at 1200kVA for two hours; (*c*) 700kV at 700kVA continuously; (*d*) 1200kV at 700kVA for two hours. The voltage output will be varied by regulators connected to the primary side of the transformers, and control desks will be installed. A 1200kV wall bushing will take the supply into the laboratory. Inside the laboratory there will be three 250kV indoor testing transformers (two mobile, one static), each with its own voltage regulator and control desk. When these are used in conjunction with the selenium-iron rectifiers, d.c. outputs up to 350kV will be obtained.

THE GOVERNMENT OF BRITISH GUIANA, through the Minister of Trade and Industry (Dr. Cheddi Jagan) has concluded negotiations for the purchase of the Demerara Electric Company, Ltd., and of additional plant and equipment for the development of the undertaking. The British Guiana Government will enter into a contract with the International Power Company, Ltd., of Canada, for the purchase of the undertaking as a going concern, on extended payment terms. In order to meet the present demand for electricity and to provide for future growth, the Government will also enter into a contract with a consortium consisting of Associated Electrical Industries, International Combustion and Taylor Woodrow for the installation of up to 3MW of additional diesel plant and of 20MW of steam plant, together with matching distribution facilities. This additional plant will be acquired on deferred terms covered by the credit facilities of the United Kingdom Export Credits Guarantee Department. The initial diesel plant will provide capacity for present demand and should be commissioned by Christmas this year.

Deaths

WE record with regret the death of Commander Christopher Michael Jacob, A.M.I.E.E., deputy technical manager of The Marconi International Marine Communication Company, Ltd., since 1954. He was fifty-four years of age and died in Chelmsford on Friday, September 2, after a brief illness.

CONTINENTAL AFFAIRS

by Our Continental Editor

Mont Blanc Road Tunnel

No. I

A road tunnel 11·6 km long which when completed will be the longest of its kind in the world, is being constructed under the Mont Blanc massif, to connect Chamonix and the Aosta Valley. Designed for an ultimate capacity of 450 vehicles per hour, the tunnel will form an important all-year-round connection between France and Italy. Driving of the tunnel is being carried out from both ends, and has now reached rather more than 30 per cent of the total length. The article outlines the scheme and describes the work of the French and Italian contractors.

WITH the completion of the Simplon and Lötschberg tunnels, the age of the great Alpine railway tunnels came to a conclusion. The formidable range of mountains, extending, in its westerly part, over an arc of 700km from the Mediterranean coast road to the Brenner, had ceased to be the impassable barrier which it had always been during the winter months.

The substantial increase in European road traffic in recent years also made itself felt on the Alpine routes, where the comparatively narrow roads, prolonged gradients, and high passes which generally remain closed altogether from October until May, are increasingly limiting the growth in particular of long-distance traffic, whether of passengers or of goods. Although pick-a-back shuttle services have for many years transported road vehicles through the principal railway tunnels—the Gotthard, the Simplon, and the Frejus—these tunnels are nearing the limit of their capacity since neither the weight of trains nor their density can be increased much further.

It is for this reason that public interest re-awakened in certain tunnel projects, some of them of quite ancient date, to be carried out in the form of road tunnels to form fast, convenient, and all-the-year-round connections across the Alps.

Two of these tunnels, the Mont Blanc and the great St. Bernhard—described in our issue for August 23, 1957, pages 279-280—are now under construction. In the present article we shall deal in some detail with the progress made on the first of these, while we hope to revert to the second in the near future. Among the projects listed in Table I, the most considerable,

TABLE I—*Alpine Road Tunnel Projects*

Site	Length, km	Est. Cost (million £)	Route
Mont Blanc	11·6	11·2	Geneva–Milan
Gt. St. Bernhard	5·8	—	Geneva–Milan
Col de la Croix	3·3	1·8	Turin–Marseille
San Bernardino	6·5	3·51	Zurich, Basle–Milan
Splügen	9·2	7·05	
Brenner	16·0 Steinach–Colle Isarco + 7·0 Colle Isarco–Vipiteno	15·5	Munich–Innsbruck

next to the Mont Blanc, is that of the Brenner, which in fact involves the building of two consecutive sections, one of 16km length from Steinach to Colle Isarco, the other 7km long from Colle Isarco to Vipiteno. Plans for a tunnel under the nearby Stelvio have also been reported.

The question of a road tunnel under the Mont Blanc formed the subject of negotiations between the French and Italian governments in the early 1950s. An agreement was signed in Paris on March 14, 1953, under which the cost (about 11·2 million pounds) is being shared between the two countries, with a contribution from Switzerland. The Italian and French companies responsible for completing the work will then form a joint operating company on a 50 : 50 basis which will administer the tunnel for seventy years, after which it will become the joint property of Italy and France. The present project is due to Professor Dott. Ing. Vittorio Zignoli of the Politecnico of Turin.

The tunnel will pass from the neighbourhood of Chamonix to Entrèves, near Courmayeur at the head of the Aosta Valley. Its length of approximately 11·6km will make it the longest road tunnel in the world, the present longest being one 8km long across the Kwannuon Straits between the Japanese islands Honshu and Kiushu. When in use it will shorten the Paris-Turin and Paris-Milan routes by 222km and 313km respectively.

Initial annual traffic is estimated at 264,000 private cars, 24,000 buses, 49,000 motor-cycles, and 15,000 lorries ; carrying 1·5 million passengers and 75,000 tonnes of freight. The amount of traffic may be expected to fluctuate considerably according to season, day of the week, and hour of the day, and this fact will be reflected in the toll charges which otherwise will depend upon the class and size of the vehicle. In the design, a maximum hourly capacity of 450 vehicles has been allowed for, and the system of ventilation which is one of the crucial points of the whole project, has been dimensioned in accordance with this figure.

Of the two concessionary companies entrusted with the carrying out of the project, the " Societa Italiana per Azioni per il Traforo del Monte Bianco " was set up on September 1, 1957. The contract for the work was awarded on May 14 1958, to " Societa Italiana per Condotte d'Acqua " which began work at the site in September of that year, commencing the driving of the tunnel itself on January 10, 1959. On the French side, the " Société Concessionaire Française pour la Construction et l'Exploitation du Tunnel Routier sous le Mont-Blanc " was constituted on April 22, 1958. The contract was awarded in January, 1959, and signed on March 4 of last year, the contractor being a group of five companies headed by Société des Entreprises de Travaux Publics André Borie, Paris, and comprising in addition the firms Compagnie Industrielle de Travaux, Régie Générale des Chemins de Fer et de Travaux Publics, Entreprise de Grands Travaux Hydrauliques, and Société Française d'Entreprises de Dragages et de Travaux Publics.

The terms provided for the driving and lining of 4850m of tunnel, within a period of thirty months, involving the excavation of 75 to 85 cubic metres of rock and the placing of 9 to 10 cubic metres of concrete per linear metre, representing a total 420,000 cubic metres of rock and 70,000 cubic metres of concrete. If the length should be extended to 5800m—half the total length—the time allowed for completion will be extended to thirty-four months (to February 15, 1962). The ventilation ducts and roadway will not be commenced until after the break-through has been achieved and the lining completed. Also excluded from the above schedule is the construction of the French access road which is the task of the Service des Ponts et Chaussées.

After completion of preparatory work, the tunnel was commenced from the French end on January 8, 1959. Here, except for a very short section near the beginning of the tunnel, rock conditions were much more favourable than on

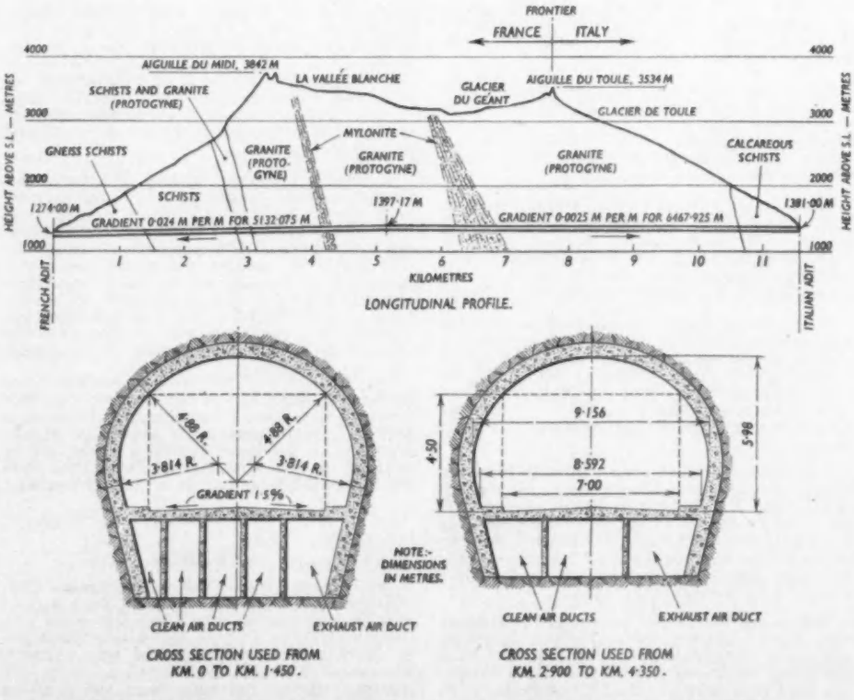


Fig. 1—Longitudinal profile of Mont Blanc tunnel and typical cross sections on French sector

the Italian side. Progress up to the end of the first week in August amounted to some 1625m, when the overburden was 610m. The maximum rate of advance achieved in a day has been 11·65m.

Project

By comparison with its great elevation—the Mont Blanc itself rises to 4810m, and there are several other peaks above or near 4000m—the Mont Blanc massif is comparatively thin, a fact which was already pointed out by the early proponents of a tunnel. As already mentioned the present road tunnel will be 11,600m long. From a point above the hamlet of Les Pélerins, some 2km west of Chamonix, it will extend in a straight south-easterly line to the Italian village of Entrèves, approximately underpassing the Aiguille du Midi (3842m), the Vallée Blanche and Glacier du Géant, and the Aiguille de Toule (3538m) (Fig. 1).

With the French and Italian adits respectively at 1274m and 1381m sea level, the overburden is considerable, exceeding 2000m over a length of tunnel of 2200m and reaching maxima of 2430m under the Aiguille du Midi and 2140m at the frontier.

It should be noted that the River Arve at Les Pélerins is at 1015m sea level, while the Dora Baltea River at Entrèves is 1300m above the sea. The mountain rises very steeply above the level of both adits and particularly on the French side the danger of avalanches from the bare upper slopes sweeping through the forest and burying the access road had to be taken into account when finally selecting the site for the adit above Les Pélerins. While the choice of a lower level for the adit appeared possible, this would have involved a rather longer tunnel and would still further have added to the overburden, as well as requiring a bigger gradient on the French section.

The actual gradients are 0·024m per metre over 5132m from the French end and 0·0025m per metre over 6468m from the Italian end, both sloping outwards.

Section.—Characteristic sections of the tunnel are shown in Fig. 1. The excavation is of horseshoe shape and varies between 75 and 85 square metres, the thickness of the concrete lining being from 0·7m to 0·9m, an area of 9 to 10 square metres.

There will be provision for two traffic lanes of 3·5m width each and two footpaths of 0·7m width raised 0·2m above the road level. The road surface will lie 5·98m below the intrados, and 3·4m above the tunnel floor, the clear width of the section at this level being 9·15m. For the traffic there will thus be a clear tunnel section of 46 square metres. Underneath the road are the ducts for fresh and exhaust air totalling 19 square metres in section, while the deck slab and supporting partitions under it amount to approximately 5 square metres, bringing the total to 70 square metres.

The normal loading gauge, for vehicles in the centre of each lane, is 4·5m high, but special loads up to 4·8m height can be conveyed through along the centre of the tunnel.

Equipment and Operation.—Lay-bys will be provided every 300m alternately on either side of the tunnel, with a turning bay for long vehicles opposite. The lay-bys will be 4·5m high, 3m wide and will have a useful length of 20m, while the turning bay will have the same height, a width of 5m and a depth of 8m. Each will include accommodation for fifteen people. Refuge niches will be provided every 100m, and both lay-bys and niches will be equipped with noiseproof telephones.

A light colour will be chosen for both the road surface and the walls, and adequate artificial lighting will be provided to enable vehicles to travel with sidelights only. Graded additional lighting over 500m near each end will be provided to prevent dazzle, and this will be controlled automatically in intensity according to conditions outside.

Three-colour light signals will be used at each adit to control the influx of vehicles, and further light signals will be placed inside to control the traffic so as to maintain an average speed of 40 to 60 k.p.h. According to the prevailing circumstances, signals will operate either automatically or manually from the two control posts at the entrances. Motor-cycle traffic police will patrol the tunnel and will keep in touch with the control posts by wireless. The patrols will be equipped to give assistance to broken-down vehicles.

Ventilation.—In a road tunnel of such length, to keep the atmosphere adequately free from carbon monoxide from the exhausts is one of the main problems which have to be solved. Since neither the draught generated by the vehicles themselves nor the chimney effect due to the difference in level of the ends are adequate, recourse must be had to forced ventilation. It was considered essential to adopt a system which did not set up a large amount of draught along the tunnel, which would be extremely dangerous in case of fire.

The decision was taken to adopt a mixed system, combining transversal and semi-transversal ventilation. At each end of the tunnel there will be a ventilator station housing blowers and exhaust fans of a combined capacity of 1500kW, i.e. 3000kW for the whole tunnel. This is sufficient to provide a total air volume of 450 cubic metres per second, enough for a traffic load of 300 vehicles per hour which will probably be the heaviest peak traffic for some years. Under average condition, the hourly traffic is expected to be about 250 vehicles, of which one-third will be heavy goods vehicles. By doubling the ventilator capacity to 6000kW, the airflow can later be increased to 600 cubic metres per second and so provide an adequate exchange of air for 450 vehicles per hour.

Centrifugal blowers will feed four conduits situated under the road surface, as shown in Fig. 1, each of which will serve a length of tunnel of 1450m. At distances of 10m there will be air outlets above the footpath on the left hand side (looking towards the Italian end). The remaining conduit—on the right-hand side, going towards Italy—will extend throughout the whole length of the tunnel and will serve to exhaust air which will enter from openings at the crown of the vault spaced 300m apart. A certain proportion of the used air will flow through the tunnel and escape at the ends, the arrangement being to have mostly transverse ventilation in the centre and mostly semi-transverse ventilation towards the ends of the tunnel. The controls will include instrumentation to record constantly the quantity of carbon monoxide present.

Access Roads.—On the Italian side access will be obtained by way of a short extension of the main road above Courmayeur.

On the French side, connecting roads will branch off the main road from Chamonix to St. Gervais, one between Chamonix and Les Pélerins, the other at Les Bossons. These will come together above Les Pélerins and rise towards the tunnel in four hairpin bends. The road will have an overall length of 4260m and a gradient of 5 to 6 per cent. The width will be 7m except for a 10m wide section from the junction to the first hairpin. The curves will have gradients of 2 to 4 per cent ; these will be 100m long, with a radius of 30m, and one will be 80m long, with a 25m radius. There will be five bridges. Near the tunnel adit, a large parking space will be established on the area of the present site camp. About 170,000 cubic metres of rock from the tunnel will be utilised in this work.

Geology.—From surface surveys the kinds of rock to be expected in tunnelling are as follows: for 2km from the French adit gneiss, mica-schists, or augengneiss, with zones of greenstone possibly enclosing asbestos. At the 2km-mark, a mylomitic enriched in quartz zone, 100m to 125m thick, may be encountered, requiring special care in the excavating work. The next kilometre consists of crystalline schists with migmatite, and occasional greenstone with asbestos inclusions. After the 3km mark one gradually reaches the protogyne (solid granite). At the Italian end, calcareous schists of poor quality occur for a considerable distance before the granite is reached.

Preparatory Work : French Side

Orders to commence were given to the French contractor on April 15, 1959, and work started the following day on a site from which trees had already been cleared. The first step was to provide access by constructing a road 2300m long from Les Pélerins, involving 30,000 cubic metres of earth movement. This reached the level of the adit on April 20, and the next stage was to build up a level working site by filling in the 80,000 cubic metres of rock. That phase was completed by the beginning of July, and the rest of the year was occupied with erecting the surface installations needed in the tunnelling work (Fig. 2).

A transformer substation of 4500kVA was set up for providing the electricity required. This was supplied from the valley by a 15kV transmission line. The compressor house contains all the air compressors with a total rating of 1900 CV ; these deliver air at 7kg per square metre through a buried main of 300mm diameter. In the traction building are serviced the battery-powered mine locomotives used in the removal of debris from the tunnel. Their batteries are charged with the aid of eight automatic chargers of 80kVA each. An important part is played by the 50 tonnes per hour aggregate plant. A proportion of the

Fig. 2—French site camp seen from a point above the tunnel adit. The temporary access road is in the centre. On the left, the compressor station and aggregate and batching plants

CONTINENTAL AFFAIRS *(Continued)*

excavated rock is tipped by the mine cars into the primary crusher which has an opening of 1·25m and after being crushed and graded is stored in silos totalling 750 cubic metres. Sand is obtained from the River Arve. The concrete is proportioned by weight in the 90 cubic metre per day mixing plant, using cement of grade "C.L.K. 250/315" made by the Chiron cement works at Chambéry and arriving by road in air-discharge bulk containers. The batches are conveyed dry into the tunnel in containers and are mixed there. Near the mouth of the tunnel is a specially heated building with shower baths and changing rooms for the workers coming out of the hot and humid atmosphere of the tunnel.

The mechanical workshop and forge contains the usual range of machine tools, lathes, milling machines, drill presses etc., required in maintenance work, and is equipped with travelling crane. The electrical shop includes facilities for the maintenance of transformers. Production of special timber shuttering is the principal task of the carpenters' shop which is equipped with band and circular saw and various types of planer.

In addition to these buildings, there is an underground explosives store for 2 tonnes of explosive, a spares store, fuel stores, and a 10m by 48m office building housing the administrative sections (accounts, costing, planning, wages, drawing office).

Accommodation for bachelors is to standards laid down by the EDF. On public land at Les Pélerins, single-storey wooden dormitory blocks have been erected. Each measures 9m by 54m and contains sixteen rooms for four persons. Hot water central heating, two communal wash rooms with six showers, and four w.c.s are provided. There is a canteen 7m by 48m with one dining room for 100 persons and another for thirty, also a first aid hut 7m by 16m with two rooms one surgery, one consulting room, and one office for the doctor.

Married quarters are between the Arve and the future Route Blanche and comprise thirty-one chalets in the local style, containing three, four, or five rooms. Each chalet is for the use of one family.

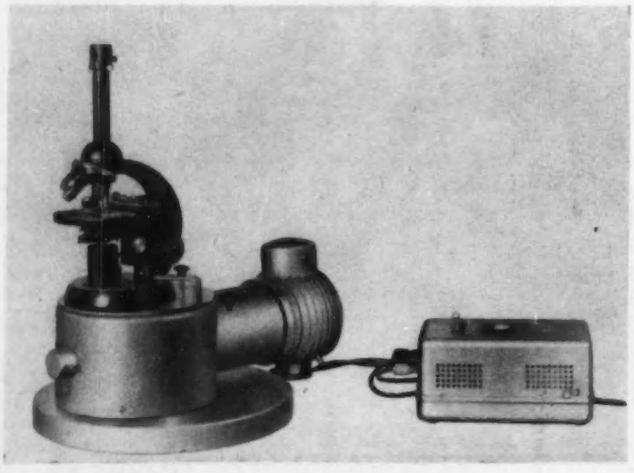
Indoor recreation facilities (television, common room) are provided at a hotel at Les Bossons rented for this purpose.

(To be continued)

Micro Projection Apparatus

Micro projection contributes a great deal to rendering scientific lectures more instructive. The equipment illustrated here, made by Carl Zeiss, Oberkochen (Württ.) (agent : Degenhardt and Co., Ltd., 6, Cavendish Square, London, W.1) is provided with an ultra high pressure mercury lamp whose image brightness far surpasses that of a d.c. arc lamp. The blue-green colour of the light is improved by filters, which are at the same time responsible for the elimination of the ultra-violet portion of the emitted rays.

Since there is no consumption of electrodes as in the case of a carbon arc lamp, the unit, it is stated, functions without any particular upkeep of the light source. Another advantage claimed is the remarkably low development of heat as well as the complete elimination of the formation of noxious gases, which tend to exert a disturbing influence especially in limited space. The apparatus is operated by alternating current so that no rectifier is required. It is conveniently portable and stated to be exceptionally simple to operate.



Micro projection equipment with high-pressure mercury lamp

De Laval Ljungström Assembly Shop

A NEW assembly shop and test bed has recently been completed at the Nacka works of de Laval Ljungström, Stockholm division. It is over 55m long and about 23m wide and has been built in such a manner that it can be extended to double this length if necessary. The entire floor area is served by a 75-ton ASEA travelling crane specially designed to require minimum headroom. It is mounted on tracks level with the tops of the side walls and carried on an independent girder construction. Provision has been made for a second similar crane to be installed later to allow the handling of loads up to 150 tons. In addition there are two 5-ton travelling console cranes.

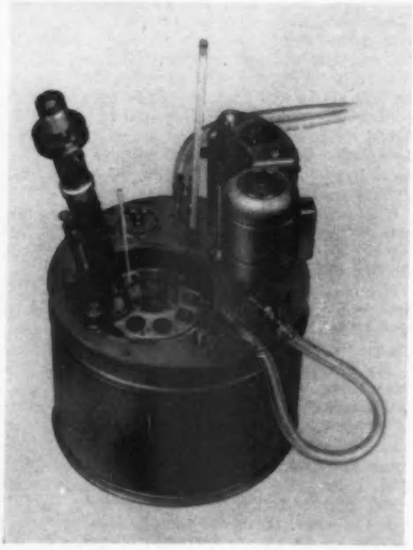
The larger part of the floor area is intended for assembly work in association with test running. The test bed area measures about 17·7m by 16m and has a floor of diagonally arranged girder rails filled in with concrete. Variations from the horizontal between any two points are within ±0·1mm.

Surrounding this area is a tunnel containing steam and lubrication lines, and cooling water pipes for use when units having their own condensers are being test run. Up to seven separate units can be coupled to the service supply lines at any one time. A La Mont boiler built by Svenska Maskinverken delivers up to 25 tons of steam per hour at a pressure of 100 kg per square centimetre and temperature of 530 deg. Cent. Steam supplies can be augmented from the older installation built to supply the original testing hall. In these circumstances, 40 tons per hour can be obtained at a pressure of 50 kg per square centimetre. Under normal conditions steam pressure of 3 kg, 12 kg, 50 kg and 100 kg per square centimetre can be selected according to the nature of the unit under test. A central condenser system together with auxiliary equipment is located in an adjoining cellar.

To ensure great stability, the whole building has been constructed on virgin rock. The windows have been specially designed to admit maximum daylight while at the same time preventing any direct sunlight falling on to the floor or the units being test run, thus avoiding expansion and contraction problems from that source. The original test hall, built in 1911, is now devoted entirely to handling smaller turbo-generating sets.

Immersion Refractometer

An improved immersion refractometer has been put on the market by Carl Zeiss, Oberkochen (Württ.) (U.K. representative : Degenhardt and Co., Ltd., 6, Cavendish Square, London, W.1.). The instrument, which is shown in the accompanying illustration, has been



Immersion refractometer

equipped with a new form of temperature control for the beakers containing the specimens. The holder with a total of nine beakers is placed directly into the thermostat, where the beakers are fully surrounded by the current of thermostat water.

For measurements on limited substance quantities, prisms have been developed whose temperature can be regulated. The surface of the measuring prism is cemented into a metal mounting with temperature control. The prism surface is placed in a horizontal position so that the specimen can be applied quite simply and rapidly.

A deviation of the path of the light rays permits the telescope of the refractometer to be in an inclined position so that the eyepiece becomes easily accessible. The position of the measuring and illuminating prism in the mounting is selected in such a manner that the specimen is illuminated with a precisely grazing incident ray of light. Measuring errors due to the finite thickness of the layer of the specimen are thus eliminated. The measuring prism can be replaced by a flow-through cell, whereby the liquid specimen can be directed to the measuring position in a continuous manner. Apart from measurements of a steadily flowing measuring substance, the flow-through cell finds application wherever the evaporation of the solvent is to be prevented.

THE AMERICAN SCENE

by Our American Editor

Alternating Gradient Synchrotron at Brookhaven National Laboratory

No. II—(*Concluded from page 448, September 9*)

The most powerful particle accelerator in the world started operation in July at the Brookhaven National Laboratory, Upton, New York, and accelerated a beam of protons to an energy of over 30,000 MeV. The machine is known as the Alternating Gradient Synchrotron (A.G.S.) and employs a new principle of focusing strong magnetic fields discovered at Brookhaven. The heart of the accelerator is an underground circular magnet 843ft in diameter comprising some 4000 tons of iron and 400 tons of copper.

Ring Acceleration

IN the linac each proton passes each accelerating gap only once. By deflection into circular orbits the protons may be made to pass many times through each acceleration station around the ring. The magnet arrangements for producing the circular orbits are discussed below. There are twelve radio-frequency acceleration stations around the ring at the points marked *X* in Fig. 1. Each station consists of a double tunable radio-frequency cavity, as shown in Fig. 7, which will impose accelerating electric forces on the proton bunches at each passage by means of a pair of accelerating gaps about 4ft apart in the vacuum chamber wall ; the gaps are made vacuum-tight with ceramic insulators. At each passage, each station accelerates the protons by 8000V, hence the protons gain about 96 keV from the twelve stations for each transit around the ring. Fig. 8 shows one of the twelve accelerating stations in the tunnel. The small cubicle to the left contains the control and auxiliary circuits for the r.f. station. The first large cubicle in the centre of the picture is the r.f. power amplifier, which provides the drive for the ferrite accelerating cavity just visible behind it. The next large cavity is the saturating supply, which tunes the ferrite cavity as the frequency of the accelerating voltage is raised. The small box hanging on the power amplifier and the cavity is used to control the amplitude of the accelerating voltage, and also provides a means for visually observing, with an oscilloscope, the wave and shape of the accelerating voltage.

On this basis, the protons must go around the ring 260,000 times, or 130,000 miles, to gain 25,000 MeV in energy. As the energy increases, the velocity of the protons increases rapidly at first and then more slowly as the protons approach the velocity of light.

Due to the velocity increase, the transit time of each proton bunch around the ring decreases. Therefore, the frequency at the accelerating stations must be increased so that the protons will arrive at the gaps in the right phase to experience a forward or accelerating impulse. The cavities are tuned to resonate at the right frequency by adjusting the permeability of the ferrite rings with which the cavities are loaded. The magnetic permeability of a ferrite is a function of the degree of constant magnetisation which may be simultaneously impressed on it by a direct current. By the ingenious double-cavity arrangement shown in Fig. 7, the d.c. saturating bias may be superimposed on the radio-frequency a.c. in the cavity walls.

The cavities are operated on the twelfth harmonic of the revolution frequency, and there are twelve equally spaced bunches of protons circulating around the ring during acceleration. Since the protons are accelerated from less than one-third of the velocity of light to within a fraction of 1 per cent of light velocity, the frequency of the accelerating cavities increases, in proportion, from 1·40 to 4·46 Mc/s. To keep them in step, the power amplifiers from the twelve double cavities are driven either in phase or 180 deg. out of phase from a common driving source. The exact frequency and phase of the driving source are governed by the revolution frequency and radial position of the proton bunches, as sensed electrically by suitably placed "pick up electrodes" within the vacuum chamber.

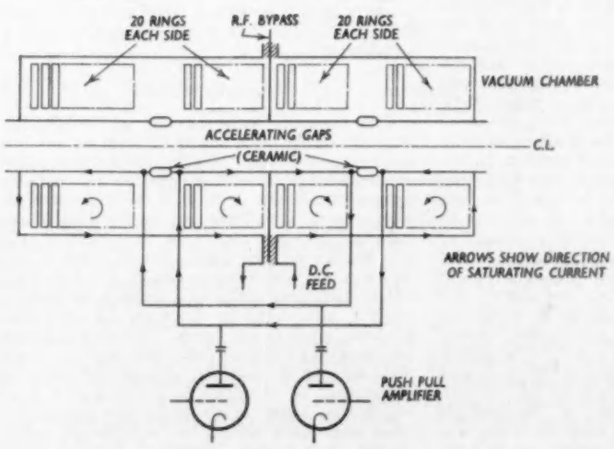


Fig. 7—Cross section of radio-frequency cavity at each accelerating station

Fig. 8—Tunnel interior with one of the twelve accelerating stations

Magnet Ring

The magnets of the machine perform two functions : guiding the proton beam into a circle and focusing the beam. The deflection of the protons into a circular path is accomplished by the force exerted on a charged particle moving across a magnetic field. This phenomenon is essentially three-dimensional and awkward to describe by two-dimensional diagrams. In the alternating gradient synchrotron the magnetic field at the median plane of the orbit (for example, the plane of Fig. 1) is directed vertically downward, from the zenith toward the centre of the earth. The protons from the linac shown at the left of Fig. 1 move southward and, being positively charged, they will experience a force toward the east which guides them into the ring. As the direction of the horizontal velocity v of the charge e changes, the direction of the deflecting force $F = Bev$ also changes so that F is always at right angles to both v and the vertical magnetic field B. This deflecting force does not change the speed of kinetic energy of a particle ; it only changes the direction of its velocity.

Each of the 240 magnets around the A.G.S. ring deflect the protons by about 1·5 deg., or 360 deg. in all to complete the nearly circular path. The reference circle is 842·90ft in diameter. The physical length of the magnets occupies about two-thirds of the circumference, the rest being available as straight sections between magnets for other equipment, such as acceleration stations and vacuum pumps, and equipment for injection, targeting, ejection and the like. A typical magnet cross section is shown in Fig. 9, which is a diagram of one of the laminations of which the magnet cores are assembled. In "open" magnets, the gap shown at the left flares away from the "back leg" at the right. There are also "closed" magnets in which the gap has an identical contour, but flares toward the back leg. The careful pole shaping is required for the focusing function of the magnetic fields.

A nearly elliptical vacuum chamber, just over 6½in by 3in inside, is centred in the gap between the magnet poles on the "aperture centre line," which lies 5·25in from the open side of the poles, where their vertical separation is 3·50in. A pressure of 10^{-6}mm Hg is maintained in the

THE AMERICAN SCENE *(Continued)*

whole vacuum chamber by forty-eight titanium getter-ion pumps distributed around the ring to prevent undue loss of protons by collision with residual air molecules. The chamber is

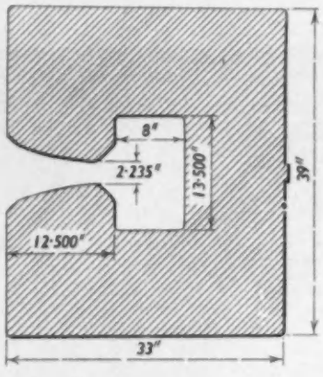


Fig. 9—Shape of A.G.S. magnet laminations

made of non-magnetic Inconel X sheet, 0·078in thick, which offers relatively high electrical resistivity against eddy currents.

Magnet Design

Fig. 10 shows an assembled magnet of the "closed" type with the magnetising coils in place. Each of the four coil sections or "pancakes" consists of eight turns of extruded rectangular copper, $1^{19}/_{32}$in by $\frac{7}{8}$in, with a $\frac{1}{4}$in diameter cooling water hole in the centre and about 0·001 ohms resistance per pancake. The closed magnet shown is 90in long and consists of about 3200 laminations of 0·035in thick magnet steel plus 1in thick end plates. It is held together by the eight longitudinal straps, which were welded to the outer periphery while the laminations were compressed by a force of 80 tons. The core shown weighs about 16 tons ; the copper weighs 3200 lb. The laminations are insulated from one another by a varnish to inhibit eddy currents. About 98 per cent of the core volume is steel. This excellent lamination factor shows that the steel produced for the A.G.S. magnets is unusually flat.

The ninety-six "closed magnets" are all of the 90in length. There are two lengths of "open" magnets ; forty-eight are 90in long and ninety-six are 75in long, giving a total of 240 magnets in the three classes : *A*, "long open" ; *B*, "short open" ; and *C*, "long closed." The flaring magnet gap is essential to the alternating gradient strong focusing system. Exceptionally stringent mechanical tolerances and magnetic uniformity are required to hold the protons within the vacuum chamber while they travel more than 100,000 miles. The roughly hyperbolic pole contour was held to ±0·002in of the prescribed form by punching the 633,000 laminations with a very accurate carbide die. The blanks were reversed right to left by pairs before punching to compensate for residual variations in thickness from side to side ; after punching, every twenty laminations were turned over, top to bottom, in stacking the magnets in order to keep the gap contour symmetrical about the median plane through the gap. The latter inverts the shearing direction in the punch and gives rise to the attractive striped appearance of the core. The tolerances on straightness of lamination stacking, and placement on the ring were all of the order of ±0·010in.

The magnets were placed by pairs on 120 large steel girders. The ends of the girders were supported on piles. Each pile cap was mechanically separated from the tunnel floor and covered four 10in "H"-section steel bearing piles driven about 50ft into the sand and gravel of Long Island, which extends hundreds of feet down and has been undisturbed for thousands of years. There are 120 sets of four piles each, and this foundation for the ring is considered to be exceptionally advantageous in view of the stability problems faced by synchrotrons constructed elsewhere. Sands acts as an effective damper for earth tremors and eliminates dangers of faults occurring in local substrata, with the accompanying physical shift of adjacent regions.

Magnet Steel

A maximum number of protons have to be held within the vacuum chamber while they travel 150,000 miles. To ensure that the various deflecting and focusing conditions shall be fulfilled uniformly all around the ring and at all times during the acceleration, the magnets must be magnetically as well as mechanically accurate. An electrical grade M-36 steel was chosen, containing about 1·80 per cent of silicon and 0·03 per cent of carbon. Before the current is turned on for a pulse, the remanent field at the aperture centre line is about 15 gauss, due to the magnetisation remaining in the steel core from the previous pulse. The value of this remanent field depends mainly on the coercive force of the steel, which averages around 0·77 oersted. As the pulse current rises, the injection field value of 120 gauss should be reached simultaneously in all magnets. The increase above remanence depends mainly on the gap size and shape, but it depends partly on the low-field permeability of the steel, which averages about 740 at 100 gauss.

During the main part of the cycle, up to 10,000 gauss and more, the fields depend almost completely on the gap geometry, because the permeability of the steel is very high. By 11,000 gauss, the saturation of the steel becomes noticeable, especially since the flux density in the pole tips near the closed part of the gap can exceed *B* at the aperture centre-line by 50 per cent or more. The onset of saturation distorts the field distribution, especially towards the closed side of the gap, and thus sets an upper limit to the proton energy that can be attained. An average permeability approaching 140 at 18,000 gauss is attained by the A.G.S. steel.

The stringent A.G.S. demands for magnetic uniformity around the ring and at all times during the rising pulse could not easily be met by commercially produced steel, even with the special care used with the 4000 tons of A.G.S. steel. Two related problems were involved : (1) coercive force and low-field permeability show standard deviations of from 10 to 15 per cent from the mean, and (2) both properties show an "ageing" deterioration of 60 per cent or more, as determined by accelerated ageing tests in which samples are subjected to a temperature of 150 deg. Cent. for five days. It is assumed that it will take many years for the same ageing to take place at room temperature. Fortunately, the high-field properties show no appreciable ageing. The first precaution taken against these large variations in the steel has been to shuffle or interleave the steel for each of the three magnet classes according to a careful plan so that the steel from a given billet and rolling mill coil appears in all magnets of a given class at the same relative position and for about the same number of laminations. This shuffling reduces the residual variations between magnets to the order of 0·1 per cent, even at injection, and minimises them throughout the ageing process extending over several decades. In addition to these measures to ensure uniformity, a number of provisions have been made for final trimming of the orbits in the machine. At each pickup electrode location, both the horizontal and vertical positions of the beam can be monitored electrically, sufficient in all to diagnose various harmonic distortions of the equilibrium orbits. On the basis of such information the correcting multiple magnets and windings to be attached, if necessary, to the outside of the vacuum chamber can be powered to hold the orbits near the centre of the vacuum chamber and to compensate, to a degree, for field distortions due to magnet saturation toward the end of acceleration.

Magnet Power Supply

As the energy of the protons increases during acceleration, their momentum *p* also increases. To hold the orbits to the over-all ring curvature set by the vacuum chamber, the deflecting magnetic fields *B* must increase in proportion to *p*. A 100-fold increase in *B* is required in a little over a second following injection at *B* = 120 gauss. The magnets are energised by passing electric currents through the coils shown in Fig. 10. To make the fields rise uniformly around the ring, the magnet coils are connected in series so that the same current will flow in all magnets. Actually there are two such series circuits, each containing two of the four pancakes on each magnet. The currents flow in opposite directions around the ring in the two series circuits in order to avoid undesirable magnetic effects of a single turn around such a large ring. Furthermore, a pulse-shaping saturating indicator is included, and the two series circuits are connected in parallel across the power supply, which consists of an ignitron-rectifier, twelve-phase 36,000kVA generator, a 47-ton flywheel, and a 5500 h.p. motor driven from 13·8kV, 60 c/s a.c. mains, shown in Fig. 11.

For top-energy protons the accelerating pulse is repeated twenty times a minute ; it consists of a current rise from 0A to 6500A in about $1\frac{1}{4}$ seconds, followed by a decrease to zero in about a second and a waiting period of less than a second before the beginning of the next pulse. Each pulse is started by firing the ignitron rectifiers in the proper phase ; this applies about 5000V to the magnet circuit. The magnet current begins to rise against the inductance and resistance of the magnet circuits. As the current rises through 45A the protons are injected from the linac, and ring acceleration begins and continues until the magnet current reaches about 145 times the injection value. At top current, about 14,000,000 joules of energy are stored in the magnetic field of the magnets, and over 10,000,000W are being turned into heat in the resistance of the magnet coils. The heat is carried away by cooling water flowing in the axial $\frac{1}{4}$in hole in the coil copper.

To bring the magnet current down to zero again, the magnetic-field energy is drawn off into the flywheel by inverting the phase at which the ignitrons are fired so that the magnet current flows against the electromotive forces generated in the alternator, causing it to act as a motor and thus speeding up the flywheel. The rotational speed of the rotating parts varies from 815 to 875 r.p.m. during the pulse, and the net electric power demand is only that required to supply the losses, i.e. enough for the 5500 h.p. motor to maintain full speed before the start of each pulse. This ingenious scheme for handling the inductive energy stored in the magnet was originally developed for the Cosmotron, whose power supply is almost as large as that required for the A.G.S., and it has proved eminently satisfactory.

Focusing Method

The research usefulness of an accelerator depends on beam intensity as well as on the top energy achieved. It is not enough to accelerate an ideal particle ; as many actual particles as possible in the vicinity of the mathematical ideal must be kept from striking the walls of the vacuum chamber and kept in phase at the accelerating gaps so that they will arrive at the target at the top energy. One may think of an actual particle as following a path which deviates radially and vertically from the ideal, nearly circular, equilibrium orbit. Focusing forces are those which tend to deflect the particle toward the ideal orbit, and the strength of focusing forces may be described by the frequency with which they cause an actual particle to oscillate back and forth across the equilibrium orbit. In the older "weak focusing" machines these

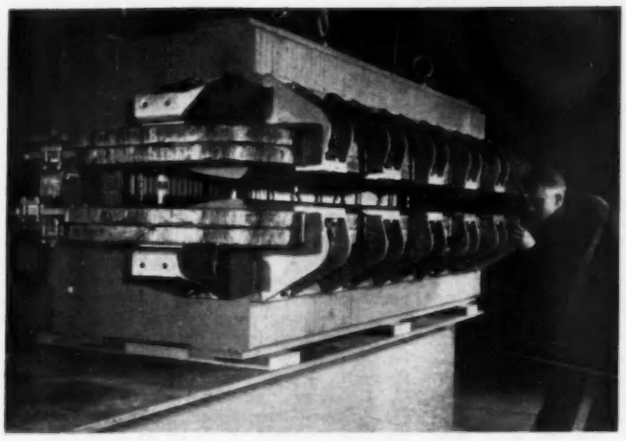


Fig. 10—One of the 240 magnet sections of the A.G.S., with coils in place

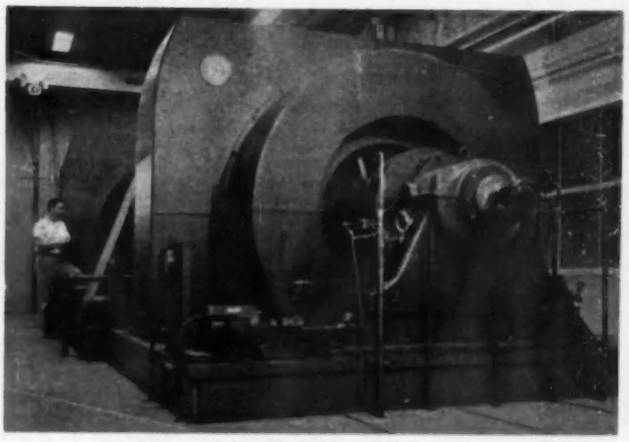


Fig. 11—5500 h.p. motor-generator set with 47-ton flywheel to store energy between pulses

" betatron oscillations " take place less than once per revolution ; in the A.G.S. there are 8¾ betatron oscillations per revolution and in the CERN proton synchrotron, there are 6¼. For this reason the term " strong focusing " has been applied to alternating gradient machines.

The A.G.S. magnets are arranged in twelve identical 30 deg. superperiods of twenty magnets each. The arrangement within a superperiod is shown in Fig. 12. Magnets 1 to 10, numbered in the direction of the proton beam, from right to left, are placed with their back legs outside the ring on five successive girders ; magnets 11 to 20 are in the same sequence as magnets 1 to 10, but have their back legs inside the ring. There are 10ft straight sections between magnets at each back-leg reversal ; 5ft straight sections for auxiliary equipment following magnets 3, 5, 7, 13, 15, and 17 ; and only 2ft straight sections to accommodate coils and vacuum chamber junctions between the rest, as shown. The sequences of ten magnets with back legs all on the same side of the orbit leave open access to the vacuum chamber on the other side ; this greatly facilitates tangential injection and ejection of the beam and leaves paths for product particles ejected from targets suitably placed in 10ft straight sections. These advantages are the main reason for adopting a basic plan in which the back legs are placed all on one side of the orbit for long intervals.

The gaps of magnets labelled " + " in Fig. 12 flare toward the outside of the ring, while those labelled " − " flare toward the inside, regardless of the position of the back legs. The + and − magnets alternate in pairs, and four successive magnets constitute one alternating gradient period. Thus, the gaps of the four short magnets adjoining each 10ft straight section flare away from their back legs ; this accounts for the ninety-six short open magnets of class *B*. It can be seen that half of the magnets of each class are placed with their back legs inside the orbit, the other half with their back legs outside. By such means a maximum over-all symmetry of the guiding and focusing fields is attained in spite of residual random variations between the within-magnet classes.

Within the flaring gap of each magnet the strength of the vertical component of magnetic field decreases toward the open side of the gap ; this means that particles are deflected less strongly in the wide than in the narrow side of the gap. With large magnetic field gradients, a + magnet tends to defocus the beam in the horizontal direction ; the converse is true for a − magnet. The essence of the alternating gradient discovery is that a regular succession of focusing and defocusing elements can produce a strong net focusing action. The phenomenon is not easy to explain in elementary terms. Both focusing and defocusing elements exert stronger forces the farther away the particle is from the equilibrium orbit. It turns out that, in focusing sections, the particles are, on the long average, farther from the equilibrium orbit than in defocusing sections. Therefore a net focusing action results.

The nature of a quasi-static magnetic field in free space is such that the " curl " of the field is zero, i.e., if the vertical upward component of the field increases as the reference point moves horizontally to the right, then the horizontal component to the right will increase just as fast as the reference point moves vertically upward. A consequence of this fact is that a + magnet, which defocuses the beam in the horizontal direction, will focus the beam in the vertical direction, and conversely. Thus, + magnets in Fig. 12 focus in the vertical direction and − magnets defocus in the vertical direction. Alternating gradient focusing is provided in both the horizontal and vertical directions, and when the same amount of strong + and − focusing is provided around the ring, the net alternating gradient focusing forces will be about the same in both the horizontal and vertical directions, i.e., there will be nearly the same number (83/4) of betatron oscillations in one revolution both vertically and horizontally.

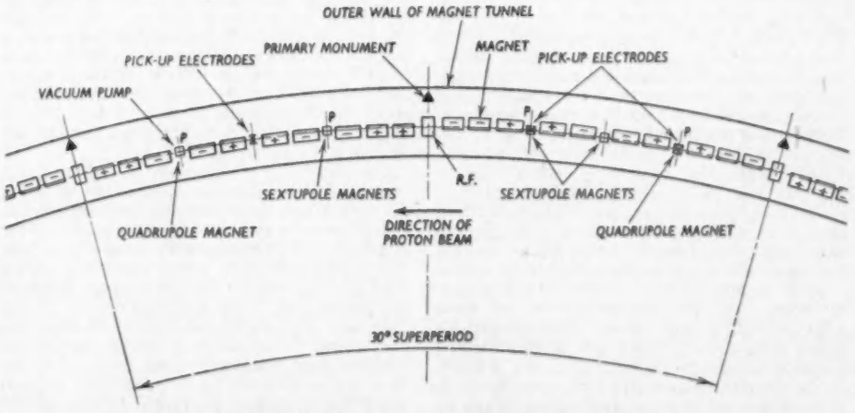


Fig. 12—Plan of one of the twelve superperiods in the magnet ring

In a linear accelerator the electric fields that accelerate the particles longitudinally in the gaps between drift tubes also tend to defocus the beam laterally. Hence, in the A.G.S. linac, magnetic alternating gradient lateral focusing is provided by placing quadruple magnets within the drift tubes. The above has considered only particles of a given energy and their lateral deviations from the equilibrium orbit for the corresponding momentum. Synchrotrons would not work at all unless a kind of longitudinal focusing could also be provided, tending to hold particles of different energies in bunches which pass the accelerating gaps in synchronism with the applied radio frequency and within a required phase interval of the radio frequency. Particles of somewhat different energies within a bunch will have correspondingly different momenta and speeds. The different momenta will have different equilibrium orbits, and the time required for one transit around the ring will depend on both the circumference of the equilibrium orbit and the speed. The facts of relativity determine this transit time.

When the mean proton kinetic energy in a bunch is below about 7200 MeV, protons whose energy is somewhat larger than the mean will tend to arrive sooner than the mean at the accelerating gaps because their transit time around the ring is smaller. If the radio frequency current is phased so that the accelerating potential across the gap is rising at each passage of the bunch, then higher energy particles, arriving early, will collect a smaller energy increment from the gap than lower energy particles arriving later. The resulting tendency to equalise the particle energies in the bunch finally causes the particles in the bunch to oscillate in energy and phase, and the frequency of this oscillation is a measure of the " bunching " forces.

Above 7200 MeV the particle speeds are already more than 99 per cent of the speed of light and therefore cannot increase much more. Protons having more than the mean energy in a bunch now tend to take longer to go around the ring because their equilibrium orbit is longer than the mean for the bunch. Thus, they arrive later at accelerating gaps, and acceleration must be phased on the falling side of the radio frequency if they are to receive smaller energy increments than the mean particle. Therefore, to preserve synchronous stability for the bunches, the phase of the accelerating radio frequency current must be changed from the rising to the falling side rather abruptly as the " transition energy " is passed. Elaborate experiments with the " electron analogue " machine at Brookhaven have shown that this phase shift can be accomplished with very little loss of beam. The " breathing " of the equilibrium orbits with changes of particle energy relative to the mean energy in the bunches contitutes a " synchrotron " oscillation which is superimposed on the betatron oscillation discussed above. The synchrotron oscillations broaden the beam in the horizontal direction only, and

THE AMERICAN SCENE *(Continued)*

this is the main reason why the vacuum chamber is made wider than it is high.

Target Building

It is hoped that a research programme can be started within the next few months, after the performance of the machine has been perfected, with a beam at full energy of more than 10,000 million protons per pulse. Most of the initial experimental work will be conducted in the Target Building. This is a large rectangular structure, 100ft wide by 250ft long and 40ft high, through which the magnet passes. A 40-ton overhead travelling crane spans its width, and 14,000 tons of heavy concrete shielding blocks cover that portion of the magnet ring that intersects the building. An extension that will approximately triple the available area will be built during the next year.

At first, target substances will be suddenly inserted into the beam in the vacuum chamber to intercept the circulating proton beam, thus producing the reactions to be studied by means of the radiations emitted. Ultimately, it is planned to deflect the proton beam out of the vacuum chamber. An external beam greatly enhances the usefulness of the machine, since it is more accessible and since many experiments can then be installed simultaneously along the path of the beam, and the direct beam used by each as needed. To provide for the emergence of selected experimental beams, channels can be formed through the shielding by re-arranging small plug blocks especially provided for this purpose at the level of the particle beam. As additional shielding for stray radiations from the A.G.S., the entire tunnel housing the magnet ring has been buried beneath a 10ft layer of earth, except that section which passes through the target building.

Research Methods

Early research with the A.G.S. at Brookhaven will be devoted to the identification of nuclear particles generated when protons from the machine collide with the nuclei of target atoms and to a thorough search for hitherto undiscovered particles which might be produced at the very high energies made possible by the A.G.S. In the multi-million electron-volt range, it has become possible to produce momentarily many new particles of intermediate masses between the electron and the proton, such as the mesons ; and others of mass greater than that of the proton, such as the hyperons ; and in addition the anti-matter or anti-particles, corresponding to most of them. It is now believed that these particles may hold the key to the basic structure of the nucleons which make up atomic nuclei. Their structure is not yet understood and new, unexplained phenomena are appearing day by day. It is generally thought that it will be necessary to accumulate a great deal more experimental information before understanding can be achieved.

One of the purposes of a high energy accelerator is to produce mesons. These particles have been found by physicists to be intimately involved with the powerful forces that hold the nucleons within the nucleus together; forces that are ultimately responsible for the form and order of the physical world and for the atom's tremendous energy. For this reason, physicists regard the study of mesons as one of the most promising sources for a fundamental understanding of the nature of matter. Mesons were first observed in 1937 in cloud chamber studies of cosmic radiation. However, physicists encountered severe handicaps in the study of mesons in cosmic radiation. They have very brief lifetimes, measured in millionths of a second or less. The processes of meson production by primary cosmic rays are in the upper atmosphere beyond convenient reach. Many different phenomena are involved under uncontrolled conditions. The need for studying the production of mesons and their interaction with nucleons under controlled conditions in the laboratory has been one of the primary incentives for building higher and higher energy accelerators. The A.G.S. will greatly extend the energies at which the production of mesons can be studied and will make available much higher energy mesons than were heretofore available for studying their interaction with protons and other atomic nuclei.

The new accelerator will also be an important and prolific source of hyperons—those elementary particles which have masses greater than that of the protons. These important members of the family of elementary nuclear particles were first discovered in cosmic radiation and then produced in relatively large numbers in the large accelerators. Their discovery was very instrumental in the development of the theory of " strange particles," which has supplied some explanations of the complex high energy phenomena.

Another of the very important purposes of this new accelerator is to produce strong beams of anti-matter, such as anti-protons and anti-neutrons. The existence of these particles was first demonstrated at the Bevatron of the University of California in 1955 and 1956. The higher energy of the A.G.S. will produce these particles in greater abundance so that their detailed properties can be studied. These investigations are expected to open a new chapter in the field of particle physics. In addition to the anti-particles of the neutron and proton, the existence of the anti-particles of several of the types of hyperons has recently been demonstrated at the Bevatron. Only a very few examples have so far been observed. It is to be expected that the number of these very heavy particles which can be produced will increase with the much greater energy available in the A.G.S.

Observations of mesons and other high energy nuclear phenomena will be made by a variety of methods. One of the newest and most important devices in the recording of high energy particle interactions is the bubble chamber. Until recently, such research was carried out by means of cloud chambers, where the speeding charged particles condensed the supersaturated vapour and left a visible trail of liquid droplets. But cloud chambers have their limitations : the density of the gas is low, which means that interesting collisions between particles occur only infrequently, and it takes a comparatively long time after one picture has been taken to clear the chamber to make it ready for the next event.

The bubble chamber overcomes these limitations by using a liquid medium, such as hydrogen cooled to a temperature of −414 deg. Fah. and under a pressure of about 70 lb per square inch. Under these conditions, hydrogen presents the characteristics of a super-heated liquid, ready to " boil " when the pressure is reduced. If a stimulus, such as a charged subnuclear particle, is introduced into the medium, boiling will begin along the track of the particle. The particle thus makes a visible track of bubbles in the liquid hydrogen, which can be photographed by special cameras located behind a glass wall of the chamber. By the synchronisation of these cameras with a high-voltage light source, together with the entering beam of bombarding particles and the piston controlling the pressure in the chamber, photographs are taken for each pulse of protons from the synchrotron. Then, by increasing the pressure, the bubbles in the chamber can be made to disappear, erasing the track and making it ready for the results of another pulse. There are six large bubble chambers now in use at the Brookhaven Cosmotron, and most of these will be used at the A.G.S. In addition, an 80in hydrogen bubble chamber, expected to be the largest in the world, is now under construction at Brookhaven.

Specially prepared photographic emulsions, arranged in stacks to provide a third dimension, are another important method whereby particle tracks can be recorded for subsequent analysis. Another important tool for research at the A.G.S. will consist of counters—both the scintillation and Cerenkov types. These devices indicate the passage of ionising elementary particles by means of light flashes. Very large and complex arrays of counters will be used to identify nuclear particles and to help in the determination of their paths and momenta.

At the present time, the staff working on the A.G.S. consists of over 170 people. The project has been under the direction of Dr. Leland J. Haworth, director of the Laboratory, and of Dr. G. K. Green, chairman of the Accelerator Development Department, and Dr. John P. Blewett, associate chairman, all of whom also played important parts in the design and construction of the 3000 MeV Cosmotron at Brookhaven

Solar-Powered Interplanetary Probes

A study has been made by Northrop International, Beverly Hills, California, of a simple solar-powered space vehicle containing only two moving parts. This was reported to the eleventh International Astronautical Congress, which last month assembled at Stockholm, by Dr. C. C. Kelber, chief development scientist of Northrop Corporation.

The vehicle he described, called the " Heliodyne," can be built with existing technology to carry out instrumented space exploration with extreme reliability. It could be placed in any desired orbit to explore all areas of the solar system, and unlike most orbiting vehicles would, in addition, be positioned at a fixed point in space relative to the earth and on the side of the earth away from the sun. To the photographic instrumentation aboard the vehicle, the sun would then be in constant eclipse. By telemetering such photos to astronomers on the earth, the " Heliodyne " would provide unlimited opportunity to study solar phenomena under ideal conditions which now prevail only on rare occasions.

The unique propulsion system providing these capabilities utilises solar-heated hydrogen and requires only two moving components, said Dr. Kelber, who with Dr. E. T. Benedikt and R. W. Halliburton, of Northrop's Norair Division Astro Systems and Research Laboratories, was responsible for the design of the vehicle. The two moving components of the system, he explained, are a louvre device to control the pressure in the hydrogen storage tank and a throttle to regulate the gas flow. Hydrogen is carried in a tank, of 1760 lb capacity, which comprises the main body of the " Heliodyne," under two atmospheres of pressure regulated by the amount of sun heat permitted through the louvres in the end of the tank.

The flow of the hydrogen is automatically controlled by the throttle system. In addition, the throttle can be adjusted by command signals from earth. In this way the acceleration of the " Heliodyne " is regulated to direct the vehicle into the selected orbit. Upon separation from a booster rocket such as the United States National Aeronautics and Space Administration's " Atlas-Centaur," three highly-reflective aluminium mirrors extend automatically from the sides of the " Heliodyne," pointing towards the sun. At the focal line of each mirror is a fine tube through which the hydrogen gas flows. As the mirrors direct the heat of the sun on to the tubes, the hydrogen is heated and expelled to produce the thrust required to equal or exceed the gravitational attraction of the sun.

The " Heliodyne " would be instrumented to gather and store information about cosmic and other radiation, magnetic fields of the sun and the planets, the activity and effect of meteorites and comets, the solar atmosphere, solar flares and solar winds as well as other long-sought astronomical data. Upon command, it would transmit this information to ground tracking stations.

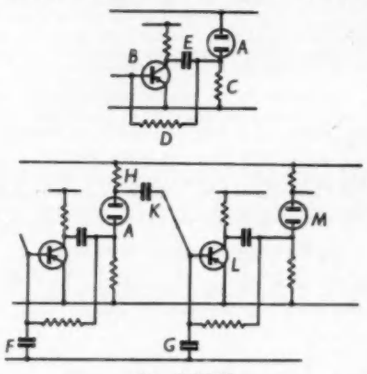
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRONICS

846,047. April 3, 1958.—BISTABLE ELECTRONIC CIRCUITS, Racal Engineering, Ltd., Western Road, Bracknell, Berkshire. (*Inventor: Herbert Henry Webb.*)

The bistable electronic circuit described in this specification includes a gas discharge indicator tube and could form the basis of an electronic counter. Referring to the upper diagram, the supply voltage to the neon *A* is selected to lie at a value between the ignition and extinguishing voltages. Initially, the neon is off and the transistor *B* is biased to cut-off. When a negative pulse is applied to the base of the transistor, it conducts and the resulting positive pulse at the collector switches on the neon. After the pulse has finished, the potential across a resistor *C* in series with the neon, due to the current flowing through the neon, holds the transistor in the bottomed state, as a result of the connection afforded by resistor *D*. If a positive pulse is now applied to the base of the transistor, the action is reversed, switching-off the neon, and the transistor is no longer held in the bottomed state. The circuit is thus bi-stable and has the advantage



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that the neon element gives a visible indication of the state of the circuit. In the form described, there is negative feedback from collector to base via capacitor *E* and resistor *D*, but this can be minimised by replacing the resistor *D* by a delay network comprising two resistors in series, the junction point of which is connected by a capacitor to the positive supply line. This has the disadvantage that the maximum speed of operation is reduced and it may be more convenient to minimise the feedback by using a low impedance for the triggering pulses. The lower diagram shows two sections of a ring counter, each section comprising a bistable circuit of the basic form described. Positive pulses are applied to the base of each transistor, via capacitors *F*, *G*, &c., respectively, and the first positive pulse will switch off any neons which are still on. If, initially, only neon *A* is on, this will be switched off, producing a negative pulse across resistor *H* which is applied through capacitor *K* to the base of transistor *L*. By suitable proportioning of resistor *H*, capacitor *K* and capacitor *G*, the pulse through capacitor *K* will exceed that through capacitor *G* causing the neon *M* to be switched on. Thus the "ON" state is moved to the next section of the ring counter at each input pulse. By connecting the output of the nth stage back to the first stage a ring counter is formed. The circuits according to the invention are also applicable to n-p-n transistors, the polarities of supplies and input pulses being inverted.—*August* 24, 1960.

ELECTRICAL ENGINEERING

844,928. July 5, 1956.—IMPROVEMENTS IN INDUCTION MOTORS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventors: Arthur Hemborough Maggs and Peter Graham Rushall.*)

In capacitor start single-phase induction motors, a starting winding connected to the supply voltage through a capacitor is employed during the starting period, and during running is either open-circuited, or connected to the supply through a capacitor of reduced capacitance, the switching required being effected either manually or, more usually, by a centrifugal switch in the motor. Unless the switching is effected at, or below, a predetermined speed, a high voltage is produced across the capacitor; consequently, when manual operation is resorted to, the capacitor employed must be one capable of withstanding the high voltage. Thus, for motors used with manual starting, an expensive paper-insulated capacitor is customarily employed instead of the cheaper electrolytic type. The object of this invention is to lessen the value of the peak voltage applied to the capacitor and thus enable the cost of the capacitor to be reduced. According to the invention, a single-phase induction motor of the type requiring a capacitor to be connected electrically in series with a starting winding has a starting winding the resistance of which is made to be at least twice that of a normal starting winding by forming the winding from a conductor having a smaller diameter than is normally required, having regard to the duty for which the motor is intended, a permanently open-circuited winding being located in juxtaposition to the starting winding with its turns electrically insulated from, but in heat exchangement with, those of the starting winding. The space saved in the slots containing the starting winding, due to the winding being formed from a conductor having a reduced diameter, is used to accommodate the open-circuited winding. The function of this winding is to act as a sump for the heat generated in the starting winding as a result of the high resistance, and thus small diameter, of its constituent conductor, and thereby to maintain the starting winding at a temperature comparable with that of a starting winding of normal resistance and thus larger diameter conductor. It may be convenient for the open-circuited winding to be formed from a conductor of the same diameter as that used for the starting winding, it being wound simultaneously with the starting winding, so that its turns lie alongside throughout the whole length of the starting winding. Both conductors may be constituted of enamelled copper wire, and may have the same diameter of conductor. As a result of the increased resistance of the starting winding, the maximum voltage across the capacitor is reduced, thus enabling a cheaper type of capacitor to be used.—*August* 17, 1960.

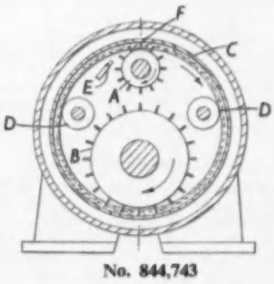
845,671. June 28, 1957.—ALTERNATING CURRENT FREQUENCY CONVERTERS, Hackbridge and Hewittic Electric Company, Ltd., Hersham Lodge, Hersham, Walton-on-Thames, Surrey, and John Glen, of the company's address.

This invention relates to alternating current frequency converters for deriving an alternating current of relatively high frequency from a supply circuit of lower frequency, for example a commercial frequency, as is required for operating induction furnaces or other heating devices employing high frequency currents. A considerable number of applications in induction heating and melting demands generation of currents in the frequency range 500–1500 c/s. The invention enables the required power to be obtained by using one or more pairs of grid-controlled rectifiers in a system of connections which permits the desirable characteristics of a rectifier of this kind to be retained when used as a frequency converter. The low-frequency supply circuit includes a transformer with a multiphase secondary system exhibiting at least one neutral point and feeding one or more pairs of grid-controlled rectifiers each of which has as many anodes as there are phases in the system; the corresponding anodes in each pair of rectifiers are connected in parallel whilst the cathodes are connected to input terminals of a winding of a high-frequency transformer, the mid-point of this winding being connected to neutral of the low-frequency supply transformer. The output terminals of the high-frequency transformer are connected to a heating coil of the device (a furnace or the like) to be supplied with high-frequency current and to a capacitance associated with the heating coil, whilst the rectifier grids are supplied with controlling electromotive force derived from the output circuit of the high-frequency transformer. The capacitance above referred to may be used for initiating the starting of the converter and to this end means may be provided for charging it with direct or rectified current before the apparatus is started into operation, so that on subsequently discharging through the heating coil it produces a train of oscillations in the heating coil and output winding of the high frequency transformer so as to start the high frequency operation of the apparatus.—*August* 24, 1960.

POWER TRANSMISSION

844,743. October 19, 1956.—CHANGE-SPEED MECHANISMS, John Constantine Grey, and John Charles Barr, both of 17, Station Road, Egham, Surrey.

Two specific constructions of a change-speed mechanism embodying this invention are described by way of example, and one construction is shown in the accompanying drawing. A driving wheel *A* and a driven wheel *B* of different diameters are journalled to rotate on parallel axes in a stationary casing. These wheels have at their peripheries short radial blades or paddles. On each side of the bladed portion of each wheel is a plain diameter portion on which rests freely a ring *C* of "U"-channel section. This ring is steadied by plain rollers *D* journalled in the casing and engaging the edges so that the ring can rotate freely when suitably impelled. Oil can be directed in a jet into the channel of the ring by a nozzle *E*. The physical principle upon which a drive is obtained is as follows. If the ring is visualised alone (without the bladed wheels) and rotating at high peripheral speed (say 500ft per second), and if a liquid is placed within the "U" section, this liquid is impelled by centrifugal force to spread evenly around the ring (as shown at *F*) and the pressures attained within the liquid vary according to dimensions and speeds, from a few hundred to several thousand lb per square inch. No power is required to maintain this pressure (except for compensating



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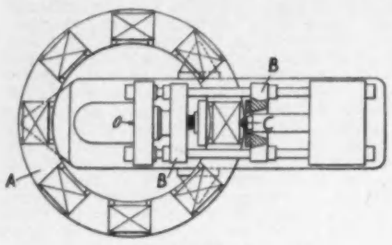
for minor losses) as the effect is purely inertial in character. In the assembly as shown with the driving wheel *A* rotating at a peripheral speed of 500ft per second, by virtue of viscous drag, the ring *C* will assume a similar speed and the wheel B, if it is devoid of any resistance, will also turn at the same peripheral speed (and lower r.p.m., due to the larger diameter). When there is a small slip between wheels *B* and *A* (say 5 per cent), due to a resisting torque, wheel *B* is forced to turn at a peripheral speed 5 per cent below that of wheel *A*. As the kinetic and pressure energies in the rotating fluid are large, the transfer of energy from the fluid to the wheel *B* is comparatively large and at a result the torque that may be transmitted to the wheel reaches the same magnitude as may be achieved at low speeds with toothed wheels. The greater the slip the greater the torque but, of course, the greater the loss. It is stated that the system becomes virtually the same as with a gear train, except that the oil replaces teeth and the drive is not "positive." An advantage is that there are no manufacturing problems of accurate tooth generation. In commencing operation the driving wheel *A* will be rotating at high speed. Oil is directed by the nozzle into the channel of the ring and caught up by the blades of the wheel *A*, rotation of the ring will gradually commence and oil will eventually fill the channel in the ring. The oil is supplied at such a rate that the channel is always full, surplus oil escaping over the edges of the channel.—*August* 17, 1960.

INJECTION MOULDING

844,867. June 27, 1958.—INJECTION MOULDING APPARATUS, Foster Yates and Thom, Ltd., P.O. Box No. 21, Blackburn, Lancashire (a communication from Roland Wucher, 20, Rue du Landy, St. Ouen (Seine), France).

An object of this invention is to reduce the time required for mould cooling and for extraction of the moulded articles on injection moulding machines. The drawing shows a plan view, partly in section, of a horizontal injection moulding apparatus constructed in accordance with the invention. With a horizontal injection moulding machine there is a rotatable annular plate or table *A* which carries a series of moulds, there being eight moulds in all in this example. The table passes between the columns and the two platens *B* of a press. Each of the press platens has a pressure plate or block so dimensioned that when the press is closed upon a mould, the left-hand pressure plate will not foul the edge of the table. Any convenient means may be provided for

rotating the table, such drive may have either manual or automatic control and its indexing arrangement is such that a mould brought between the press platens and in alignment with the pressure plates. The press is then operated to close the mould under the desired pressure and at the same time brings the injection orifice into engagement with an injection nozzle *C* of the moulding machine. As soon as the injection operation has been completed, the press platens are separated to release the mould and the injection cylinder is withdrawn. The table is then rotated to move the mould from



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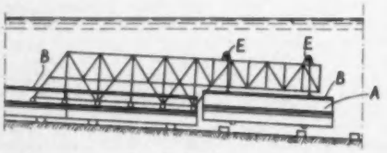
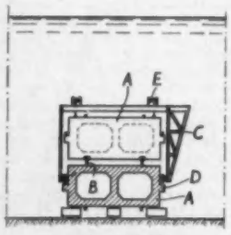
between the pressure plates and bring the next mould into position for a moulding operation. It will be seen that with this arrangement the operations of cooling the mould and removing the moulded article do not involve a loss of time, since the period occurs only in its proper relation with the rotation of the table. The closing of the press platens upon the mould results in a displacement of the mould towards the injection nozzle of the press. To permit this action the moulds are slidably mounted in radial guides on the table. Such mould displacement may be relatively small, and it may be provided for by appropriate displacement of the table.—*August* 17, 1960.

CIVIL ENGINEERING

845,180. November 28, 1958.—LAYING SUBMERGED TUNNEL UNITS, Christiani and Nielsen A/S, Vester Farimagsgade 41, Copenhagen, Denmark.

The invention relates to a method and apparatus for laying units in series for the construction of submerged tunnels. Its general object is to provide a method and apparatus whereby it is possible to transport the tunnel units to their desired positions without having to work from the surface of the water and without the use of special floating cranes or other gear. In the embodiment shown, the tunnel consists of units *A* which are laid either on the levelled bottom of a water course or on foundations or other supports. Longitudinal tracks *B* mounted on the top surface





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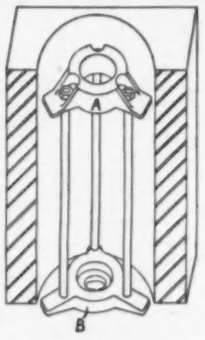
of the units form continuous rails when the units are placed end to end. The bottom surface of each unit is provided with wheels corresponding to the tracks and projecting as little as possible beyond the bottom surface. Units are run on their wheels along the tracks to the end of he series laid. To lower a unit into place beyond the free end of the series laid, the present invention provides a gantry *C* on wheels to run on tracks mounted on brackets *D* formed on the sidewalls of the units. New units are advanced along the top of the previously laid units and carried in through the opening in the rear of gantry and suspended from a winch *E*. The crane then travels forward, so that the unit hangs from the winch beyond the free end of the series and is then lowered upon the prepared foundations. When the tunnel unit has been lowered and pulled up against the free end of the series it is released from the winch and coupled up to serve as a track for the laying of the next tunnel unit in the same manner.—*August* 17, 1960.

NUCLEAR ENGINEERING

844,606. October 10, 1956.—FUEL ELEMENTS FOR NUCLEAR REACTORS, British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2, and Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, 1-3, St. Paul's Churchyard, London, E.C.4. (*Inventors: Selchouk Ahmed Ghalib, Douglas Francis Welch, Derek Randall Smith and Geoffrey Alfred Roberts.*)

This invention relates particularly to fuel elements for solid, e.g. graphite moderated reactors and its main object is to provide an improved arrangement for supporting the elements in cases in which they are stacked vertically. From the drawings, which show by way of example several embodiments of the invention, we reproduce one which shows a cage for a fuel element and in which the ends of the cage are spaced apart by rods. A unit block of a solid moderator which will be assumed to be graphite has a vertical fuel channel bored through it and extending



No. 844,606

through the core. Each fuel element is mounted in a cage and these cages are stacked vertically in the channels. An actual fuel element, which is not shown, would be in the form of a rod of fissile material encased in canning having external finning. The cage serves both to locate the fuel element and also relieve it of the weight of the elements stacked above it. Each cage comprises an upper element *A* having radial lugs which are coupled by vertical rods to corresponding lugs extending radially from a lower element *B*. The lower element is formed with a circular recess in which the lower end of the fuel element rests and is centralised. The upper member *A* similarly has a central aperture which surrounds the end of the cylindrical fuel element and not the fins. The outer ends of the lugs form a sliding fit against the walls of the channel and the length of the fuel element is such that it does not reach to the upper face of the member *A* so that it will not carry the weight of the elements above. The metal employed for the cage is conveniently beryllium. An alternative arrangement shown is designed to minimise the amount of beryllium employed.—*August* 17, 1960.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Sept. 16.—STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Control Centres for Modern Industry," H. B. Davies, 7.30 p.m.

Mon., Sept. 19.—BOURNEMOUTH AND DISTRICT BRANCH: Grand Hotel, Firvale Road, Bournemouth, "Railway Electric Locomotives," D. B. McKenzie, 8 p.m. ★ BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Bristol, Chairman's Address, and "Refrigeration Reflections," R. C. Wilkes, 8 p.m.

Tues., Sept. 20.—OXFORD AND DISTRICTS BRANCH: Employment Exchange, Oxford, "Lighting Techniques in Shops and Stores," J. A. Hall, 8 p.m. ★ PORTSMOUTH AND DISTRICT BRANCH: Committee Rooms, Ministry of Labour Offices, Lake Road, Portsmouth, "Variable Speed A.C. Motors," 7.30 p.m.

Wed., Sept. 21.—READING AND DISTRICTS BRANCH: Visit to Works of J. G. Statter and Co., 2.30 p.m.

Thurs., Sept. 22.—SOUTHAMPTON BRANCH: Cathedral Hotel, Salisbury, "The Association," E. K. Brittain, 7.30 p.m. ★ SOUTH LONDON BRANCH: Greyhound Hotel, High Street, Croydon, Surrey, Film "Diesel Engines" and "The A.S.E.E.," E. A. Bromfield, 8 p.m.

BIRMINGHAM SCIENCE MUSEUM

Thurs., Sept. 29.—Museum of Science and Industry, Newhall Street, Birmingham, 3, "Live Steam Operation of Five Engines," evening until 9 p.m., additional to regular "Steam Week-ends."

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 21.—SOUTH WALES SECTION: Welsh College of Advanced Technology, Cardiff, "A Vidicon Television Camera Channel," B. S. Pover, 6.30 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Sept. 17.—Tudor Room, Caxton Hall, London, S.W.1, "Programme for the Surface Exploration of the Moon," P. A. E. Stewart, 6 p.m.

COLLEGE OF ADVANCED TECHNOLOGY

Thurs. and Fri., Sept. 22 *and* 23.—College of Advanced Technology, Gosta Green, Birmingham, 4, Joint Symposium with the Institution of Gas Engineers, and the Society of Chemical Industry, Corrosion Group on "The Protection of Gas Plant and Equipment from Corrosion," 9.30 a.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Thurs. and Fri., Sept. 22 *and* 23.—J. J. Thomson, Physical Laboratory, The University, Reading, Conference on "Diamond Physics." *Thurs., Sept.* 22.—Duddell Medal Presentation, "Some Developments of the Optical Lever," R. V. Jones 5 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Sept. 19.—NORTH STAFFORDSHIRE BRANCH: North Staffordshire Technical College, Stoke-on-Trent, Films, 7.15 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., Sept. 20.—Lecture Hall, Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Presidential Address, D. C. Brown, and Ordinary General Meeting, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Sept. 17.—NORTHERN IRELAND GRADUATES' SECTION: Visit to Maydown Industrial Estate, Londonderry, 8 p.m.

Tues., Sept. 20.—SOUTH WALES BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, Chairman's Address, T. G. Dash, 6 p.m.

Wed., Sept. 21.—NORTH WESTERN GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, Annual Branch Chairman's Address, G. McOnie, 7 p.m.

Fri., Sept. 23.—NORTH EASTERN GRADUATES' SECTION: Rutherford College, Newcastle upon Tyne, Chairman's Address, "Oil Field Engineering and Drilling for Oil," 6.30 p.m.

INSTITUTION OF PLANT ENGINEERS

Wed., Sept. 21.—KENT BRANCH: King's Head Hotel, High Street Rochester, "Insulation of Factories and Buildings," N. Foster, 7 p.m.

Thurs., Sept. 22.—MERSEYSIDE AND NORTH WALES BRANCH: Exchange Hotel, Liverpool, "Some Engineering Problems with Chemical Plant," J. C. Veale, 7.15 p.m.

Mon., Sept. 26.—WEST AND EAST YORKSHIRE BRANCH: Houldsworth School of Applied Science, The University, Leeds, "Fuel-Economy and Productivity," K. Higginson, 7.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed. to Fri., Sept. 21 *to* 23.—PLASTICS AND POLYMER GROUP: William Beveridge Hall, Senate House, University of London, W.C.1, Symposium on "High Temperature Resistance and Thermal Degradation of Polymers."

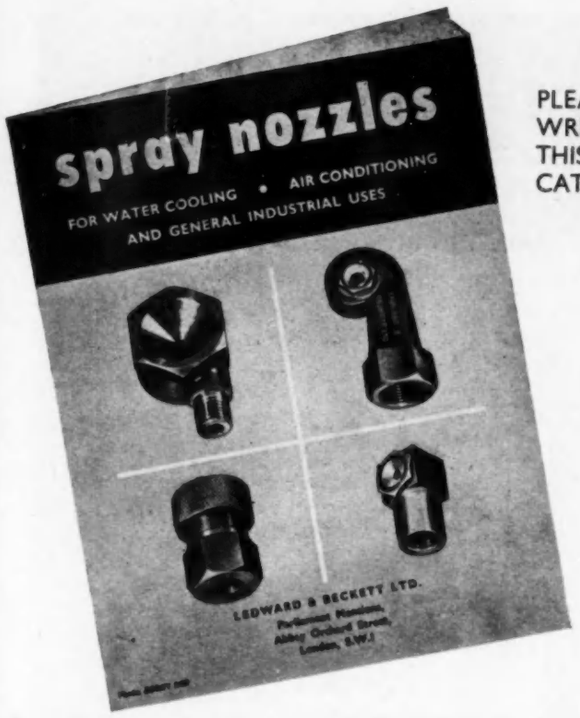
Advanced Engineering Courses

Direction and Supervision of Scientific and Engineering Personnel. NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, St. John Street, London, E.C.1. The course is meant for senior managers and consists of sixteen full days at fortnightly intervals commencing October 12, 1960. Its purpose is to increase effectiveness in the supervision of scientific and engineering personnel and in organising their work so that their technical knowledge and abilities may be used to the full—by recognising the specific problems in this field and by appreciating the role of individual personality and outlook in allotting duties and defining areas of responsibility. Fee 50 guineas.

The Design of Equipment for Human Use. ENGINEERING AND ALLIED EMPLOYERS' WEST OF ENGLAND ASSOCIATION, Engineers' House, The Promenade, Clifton Down, Bristol, 8. The course is intended for staff concerned with the design of machines and equipment which have to be manually operated or controlled. It is of two weeks duration, commencing November 21. Tuition fee £40.

Post-Graduate Evening Courses in Civil Engineering. BATTERSEA COLLEGE OF TECHNOLOGY, Department of Civil and Mechanical Engineering, Battersea Park Road, London, S.W.11. "Traffic Engineering," eleven lectures to be held on Monday evenings from 7 to 9 p.m., commencing October 3. Fee £1; "Structural Design in Aluminium," six lectures to be held on Monday evenings from 7 to 9 p.m., commencing October 10. Fee 10s.; "Theory and Design of Prestressed Concrete," ten lectures to be held on Tuesday evenings from 6.45 to 9 p.m., commencing October 4. Fee £1; "Elements of Law Relating to Civil and Mechanical Engineering"; five lectures to be held on Tuesday evenings from 6.45 to 8.45 p.m., commencing November 1. Fee 10s.; "Buckling and Instability in Structures,"; six lectures to be held on Wednesday evenings from 6.45 to 9 p.m. commencing October 5. Fee 10s.; "Dynamic Behaviour of Structures,"; ten lectures to be held on Thursday evenings from 7 to 9 p.m., commencing October 6. Fee £1; "Theory and Design of Circular Cylindrical Shells"; eleven lectures to be held on Friday evenings from 6.45 to 9 p.m., commencing October 7. Fee £1; "Structural Analysis by Influence Coefficients"; eleven lectures to be held on Monday evenings from 6.45 to 9 p.m., commencing January 9. Fee £1; "Highway Bridge Design"; ten lectures to be held on Tuesday evenings from 6.45 to 9 p.m., commencing January 10. Fee £1; "Structural Design in Timber,"; eleven lectures to be held on Friday evenings from 6.45 to 9 p.m., commencing January 13. Fee £1.

Work Study. BOROUGH POLYTECHNIC, Borough Road, London, S.E.1 The course is intended primarily for those students already in possession of a Higher National Certificate and being prepared for endorsement examinations of the Institution of Mechanical Engineers and the Institution of Production Engineers. Because of continued demand, a duplicate part-time day course is being introduced for this coming session. Students may attend for one morning or one evening per week for two years, and the sessions extend for about thirty weeks from mid-September until early June. The current inclusive fee is £1 14s. per annum. Arrangements for next session are: Enrolment, Monday and Tuesday, September 19 and 20, 9.30 a.m. to 12 noon for the part-time day course, 5.30 to 8. p.m. for the evening course. Classes commence Monday, September 26, 6.30 to 9 p.m. evening course. Tuesday, September 27, 9.30 a.m. to 12 noon part-time day course.



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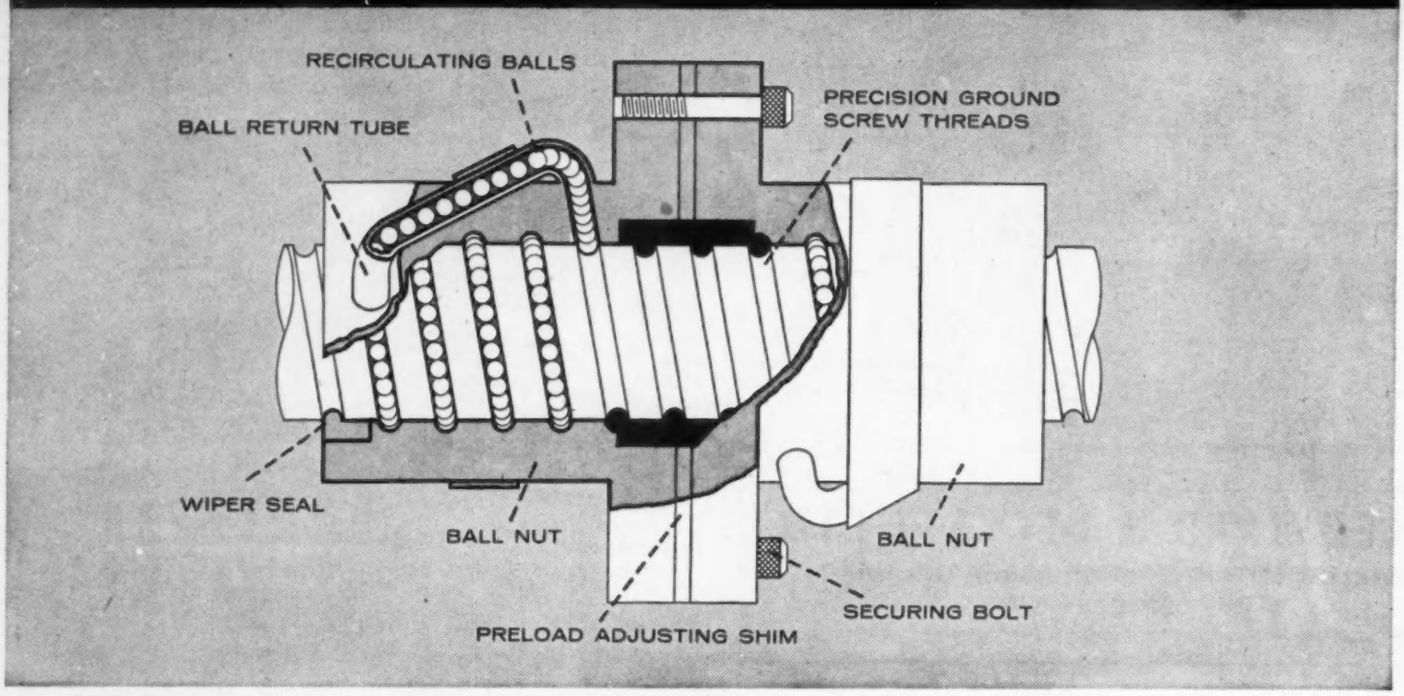

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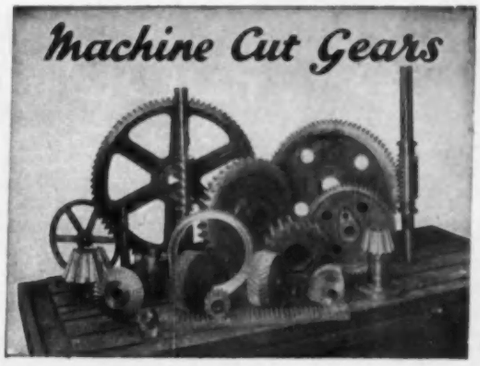

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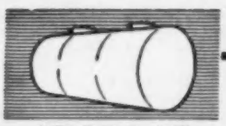

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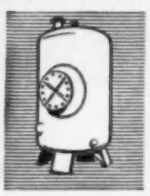

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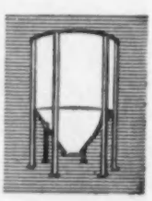

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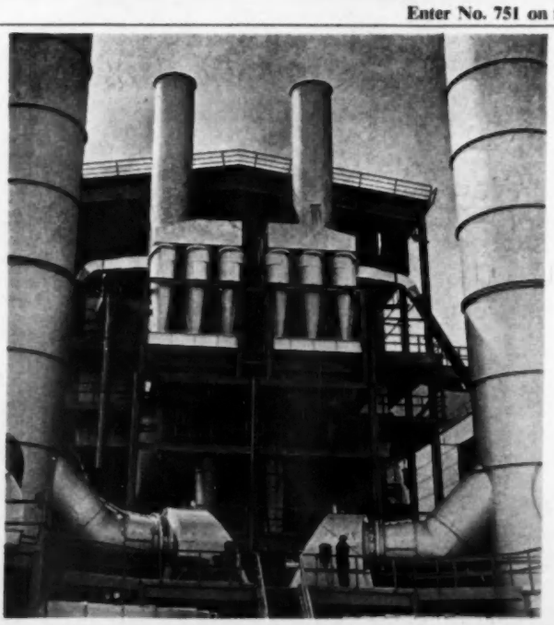

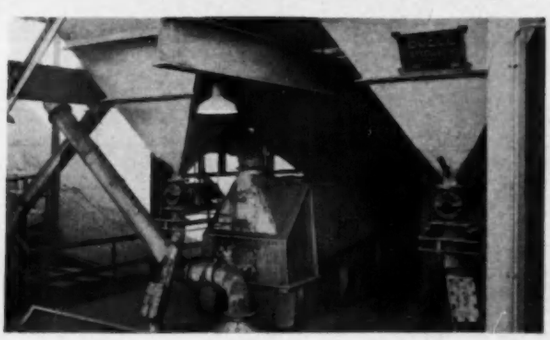

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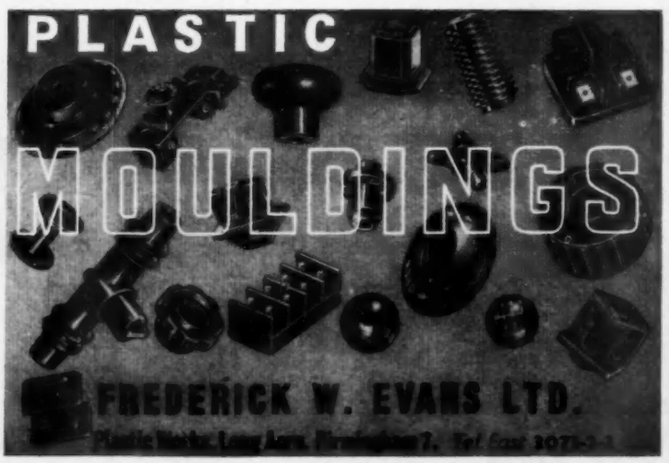

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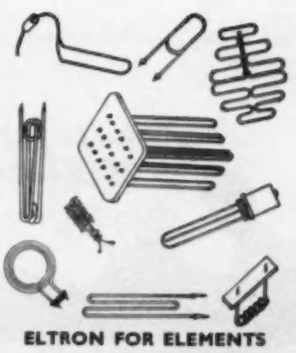

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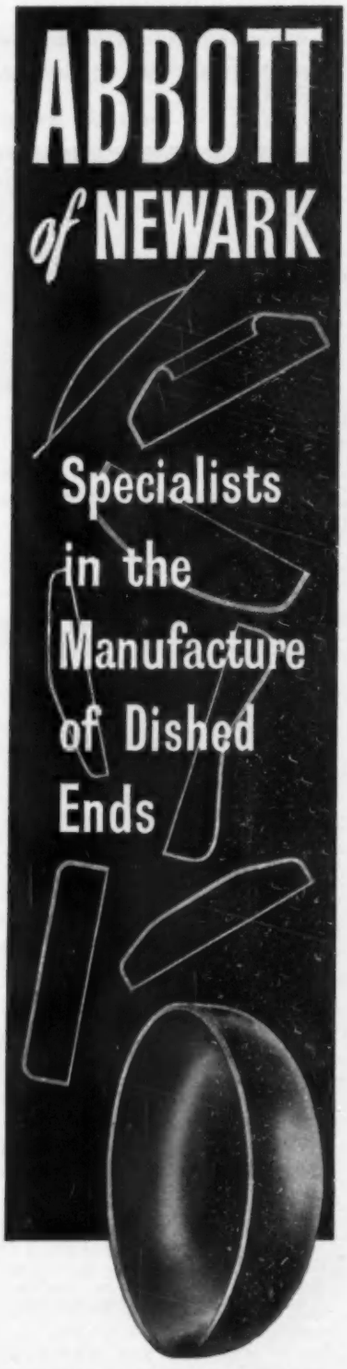

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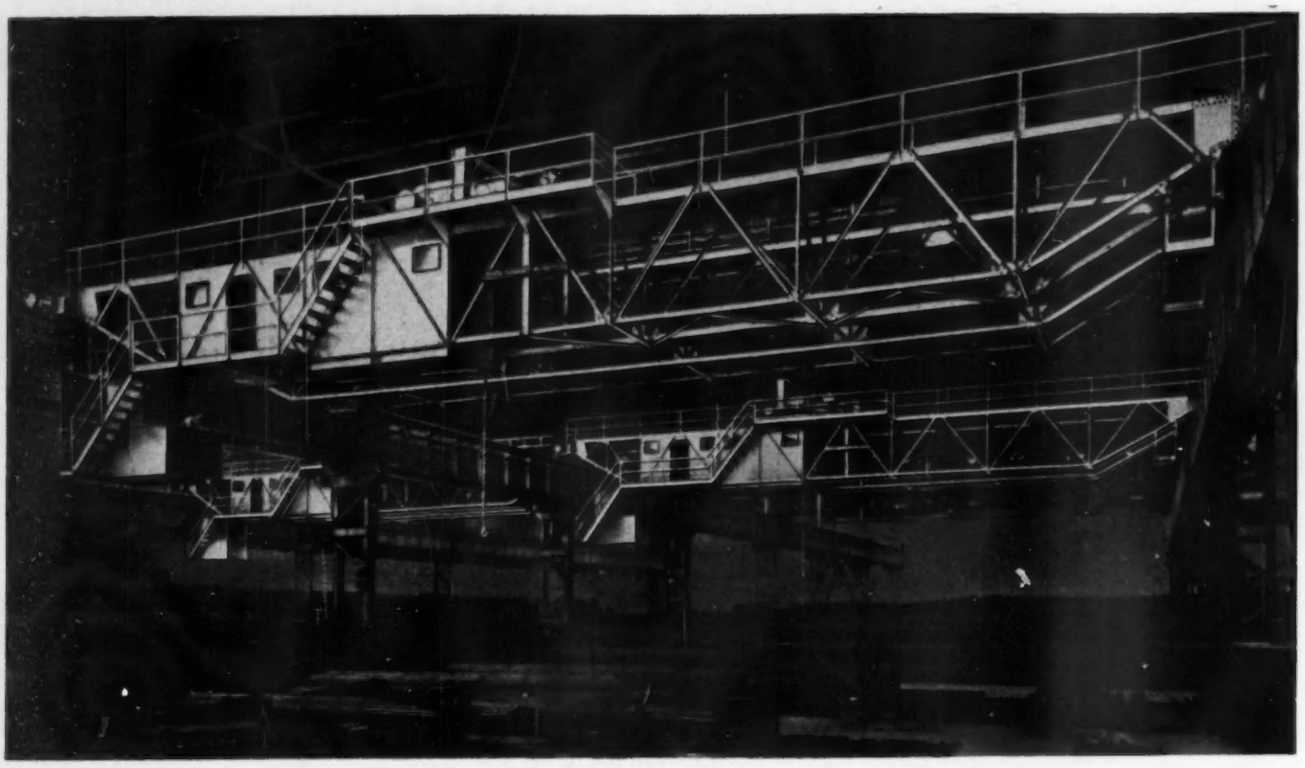

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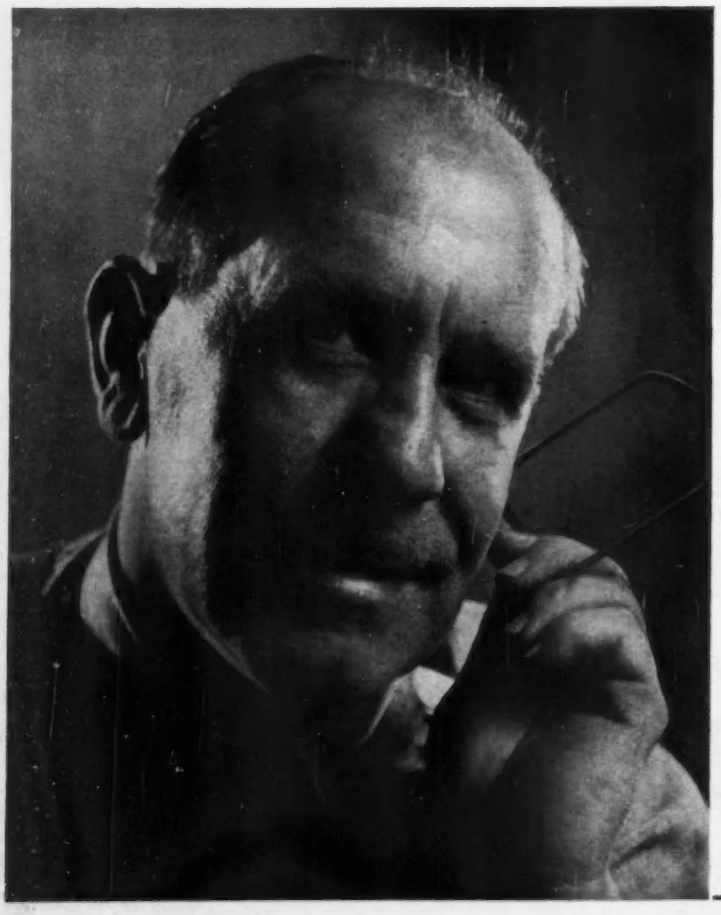

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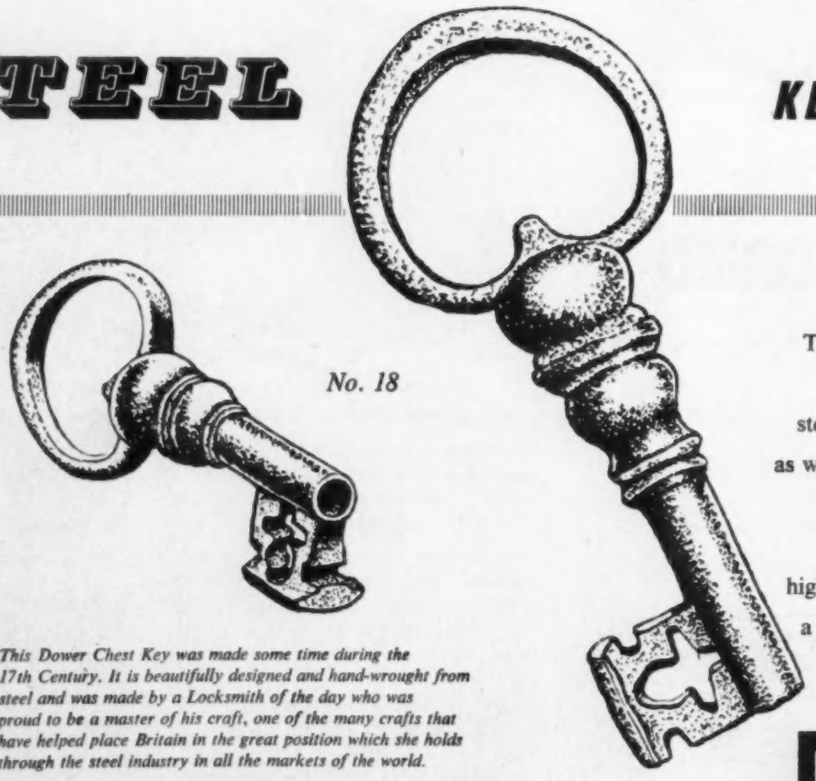

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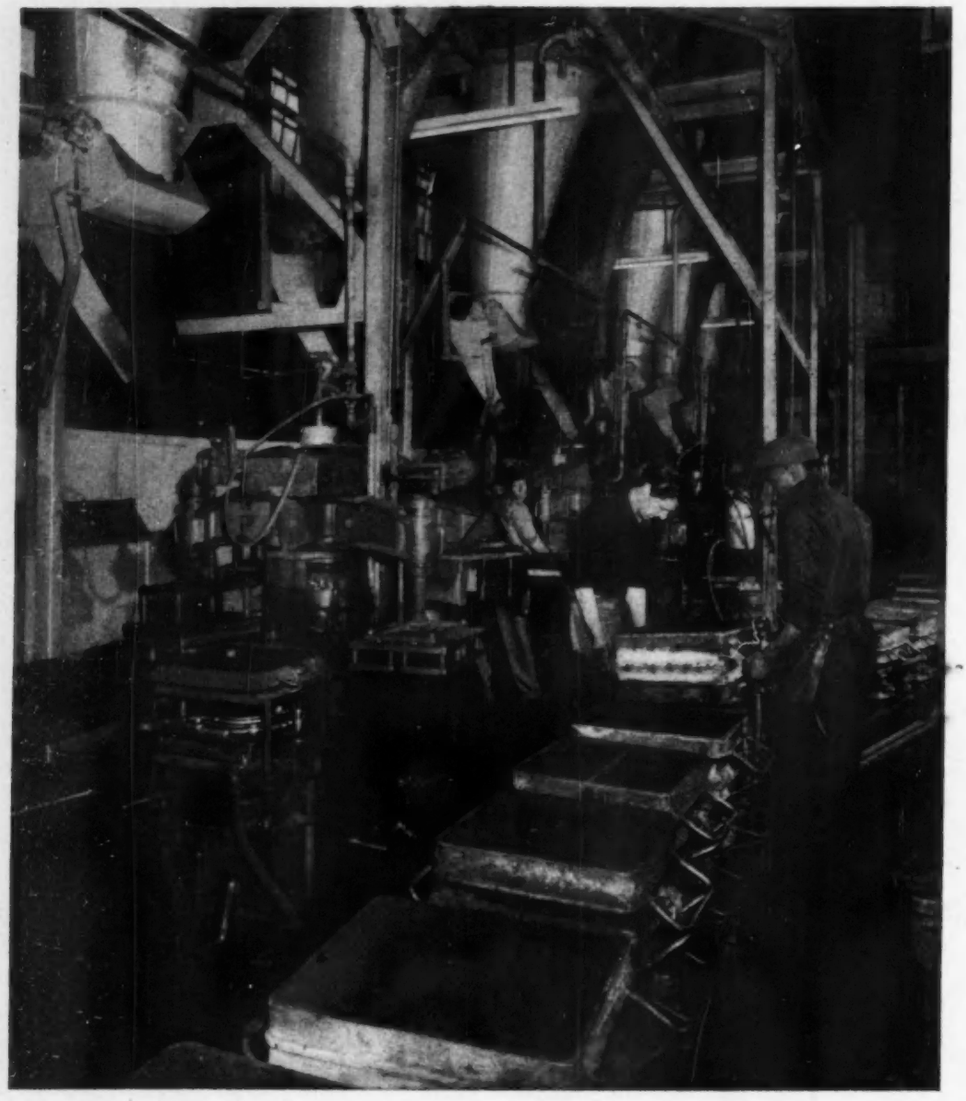

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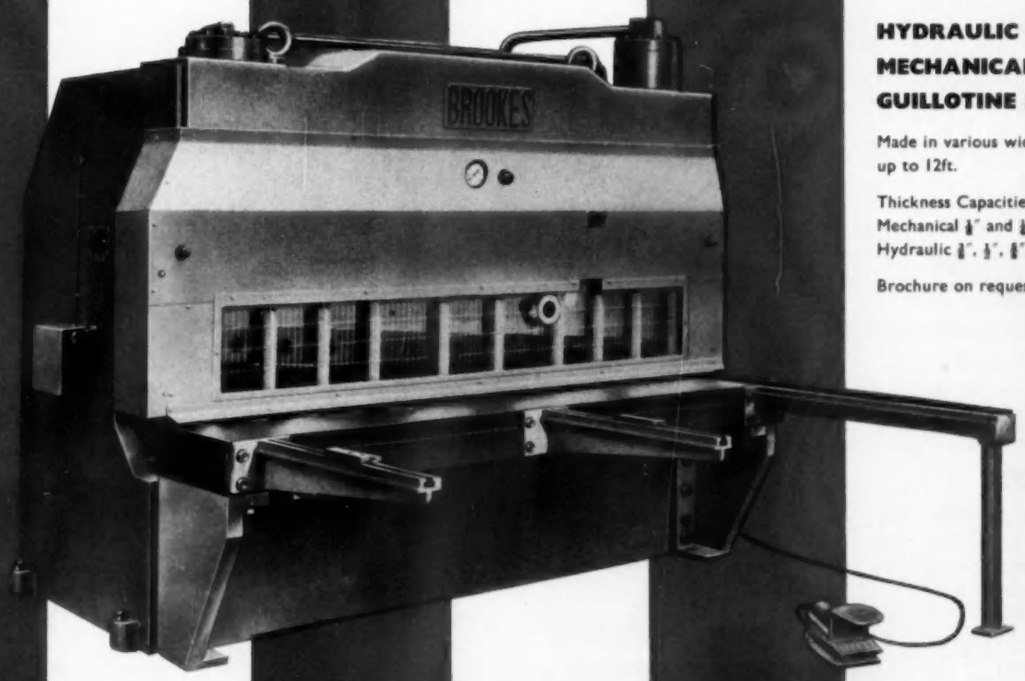

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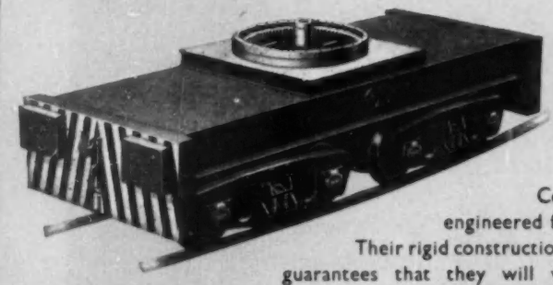

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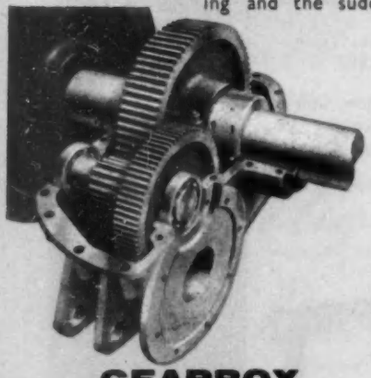

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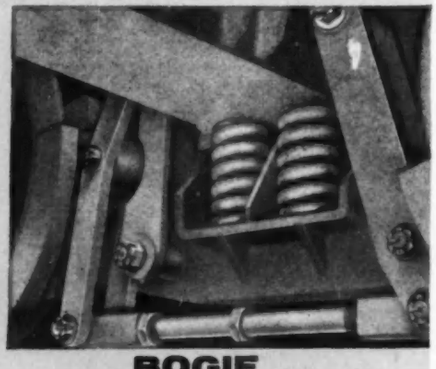
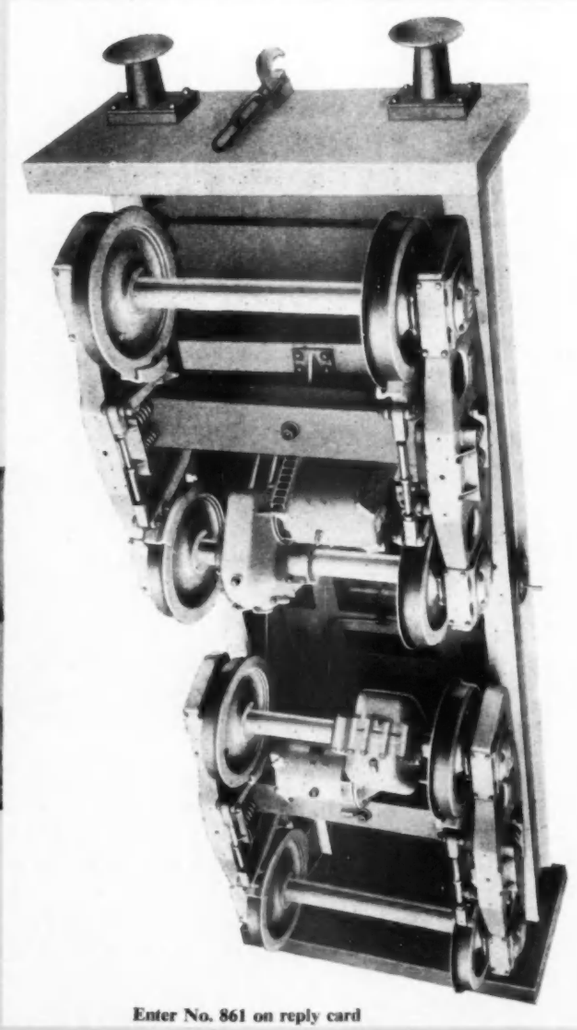
All gearing is totally enclosed in cast steel gearboxes. These house accurately machine-cut steel spur gears constantly enveloped in a protective oil film, coupled to independently mounted electric motors.



BOGIE SUSPENSION

The frame is mounted on heavy-duty sprung twin bogies each having four single flange steel rail wheels and one driven axle. Robust coil springs absorb all shock loads produced by travelling over uneven track.



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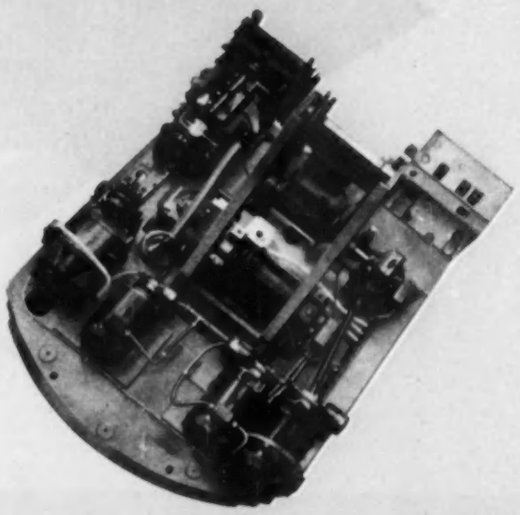
The operators cab, designed for maximum functional efficiency and comfort, provides an all-round view of the working area. Full weather protection is assured and fan or heater can be fitted to suit various climates.

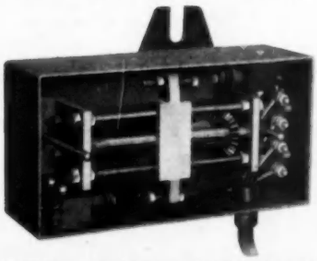


CLEAN SIMPLE LAYOUT

This clean, simple layout means ready accessibility and easy maintenance. A separate electric motor for each crane motion is powered by a variable voltage generator which is, in turn, driven by a diesel engine.

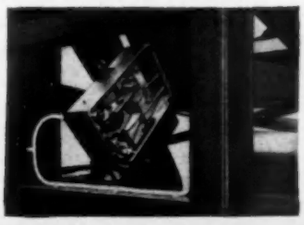
LIMIT SWITCHES

Self-resetting limit switches automatically operate should attempts be made to hoist or derrick beyond permitted limits.



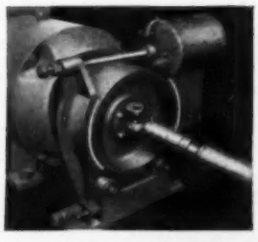
SAFE LOAD INDICATOR

Coles safe load indicator automatically prevents lifting of an unsafe load irrespective of the jib position.



ELECTRO MECHANICAL BRAKES

Electro-mechanical brakes, fitted to all crane motions, are immediately and automatically applied should the supply of current be interrupted for any reason.



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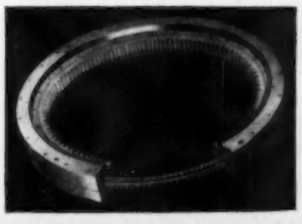
The superstructure revolves on a large diameter double live ring of steel balls running in hardened races, thus obviating the need for a centre post.



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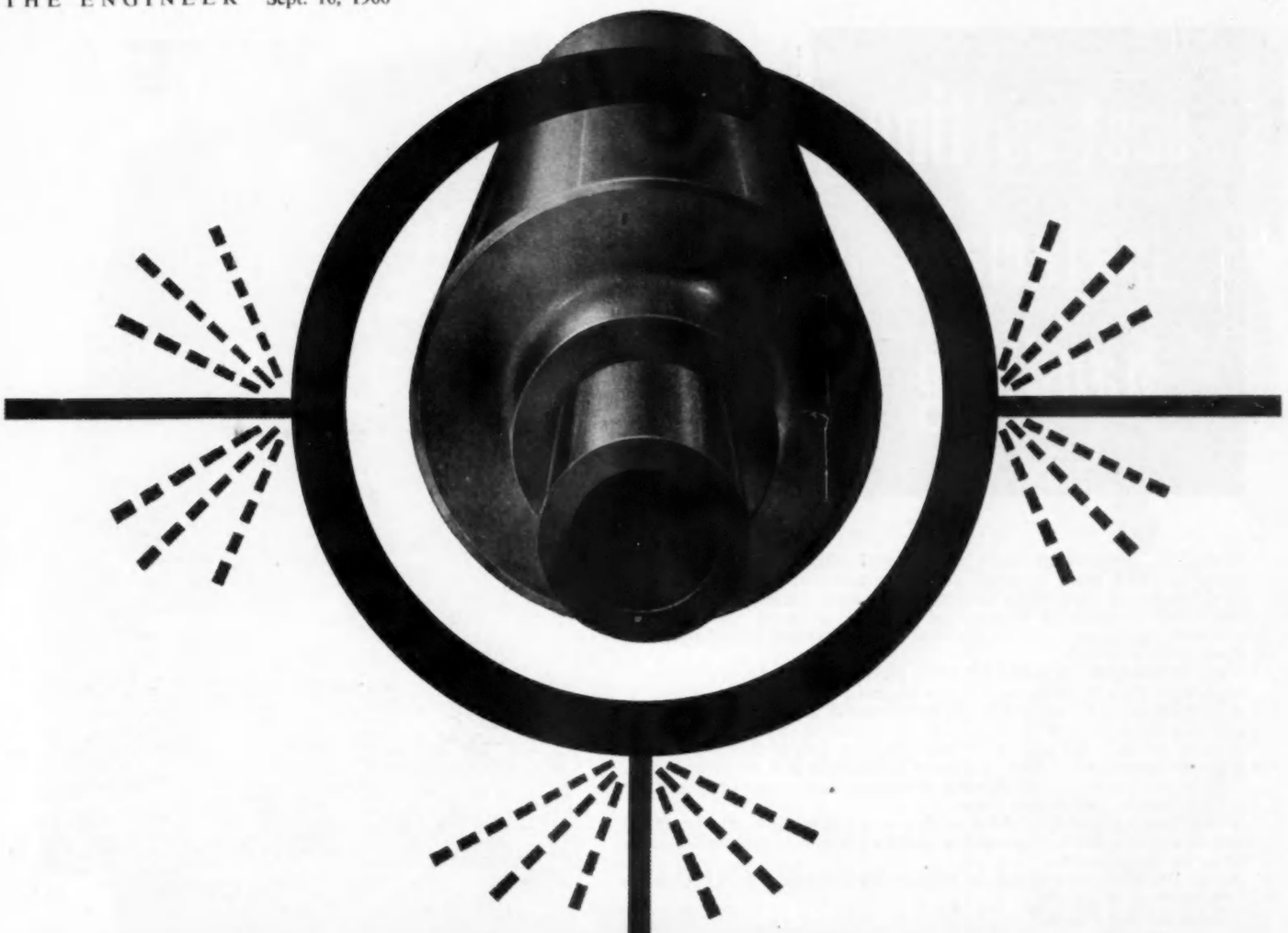

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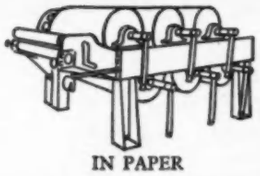

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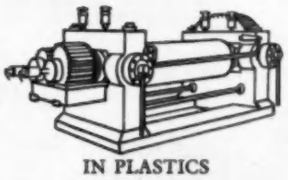

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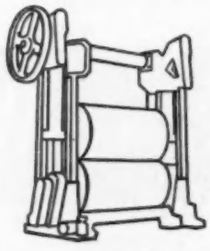

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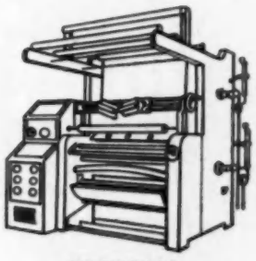

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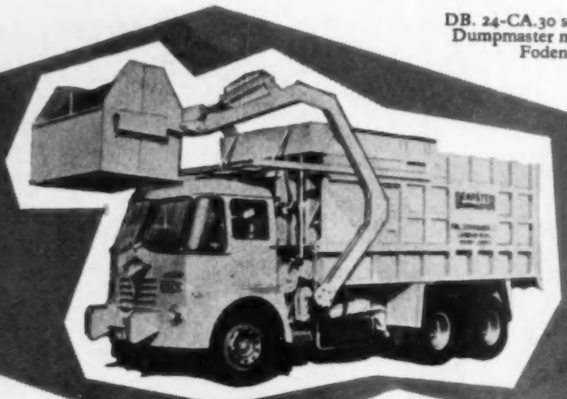
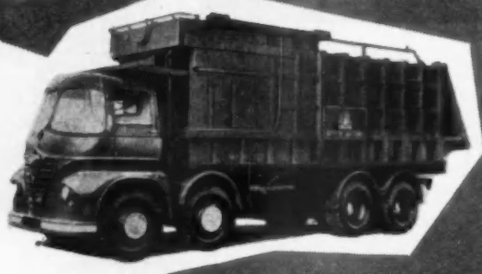


DB. 24-CA.30 self-loading Dumpmaster mounted on Foden 6-wheeled chassis.



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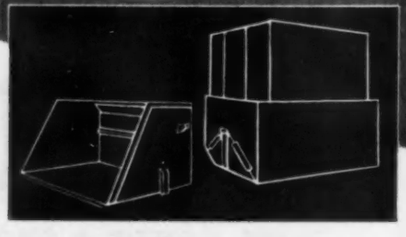
Model 22,000 T Dinosaur transfer loader mounted on Atkinson 6-wheeler.



Dempster-Dumpster LFW 253-C container servicing unit mounted on 5-ton Austin chassis.

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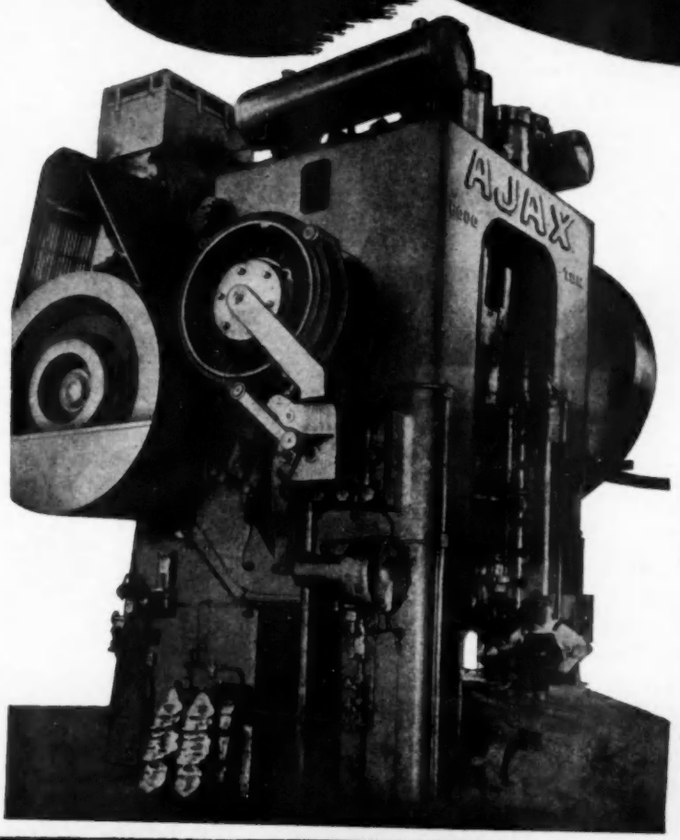

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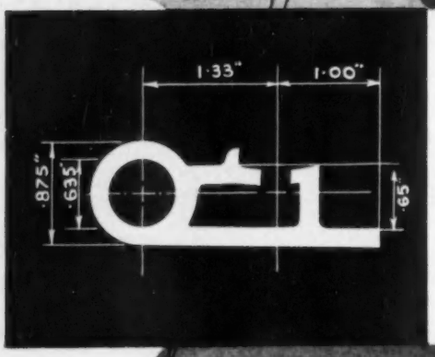

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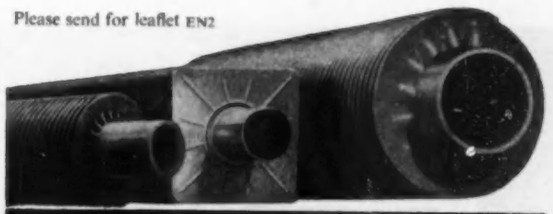

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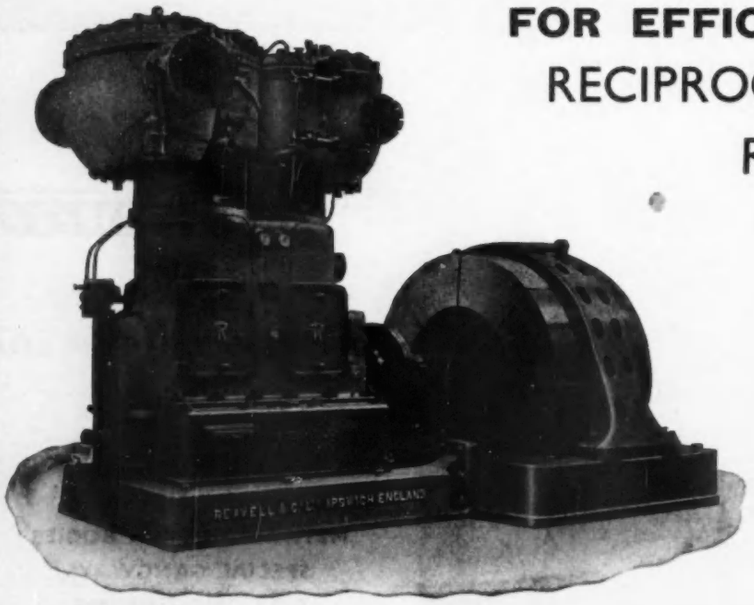

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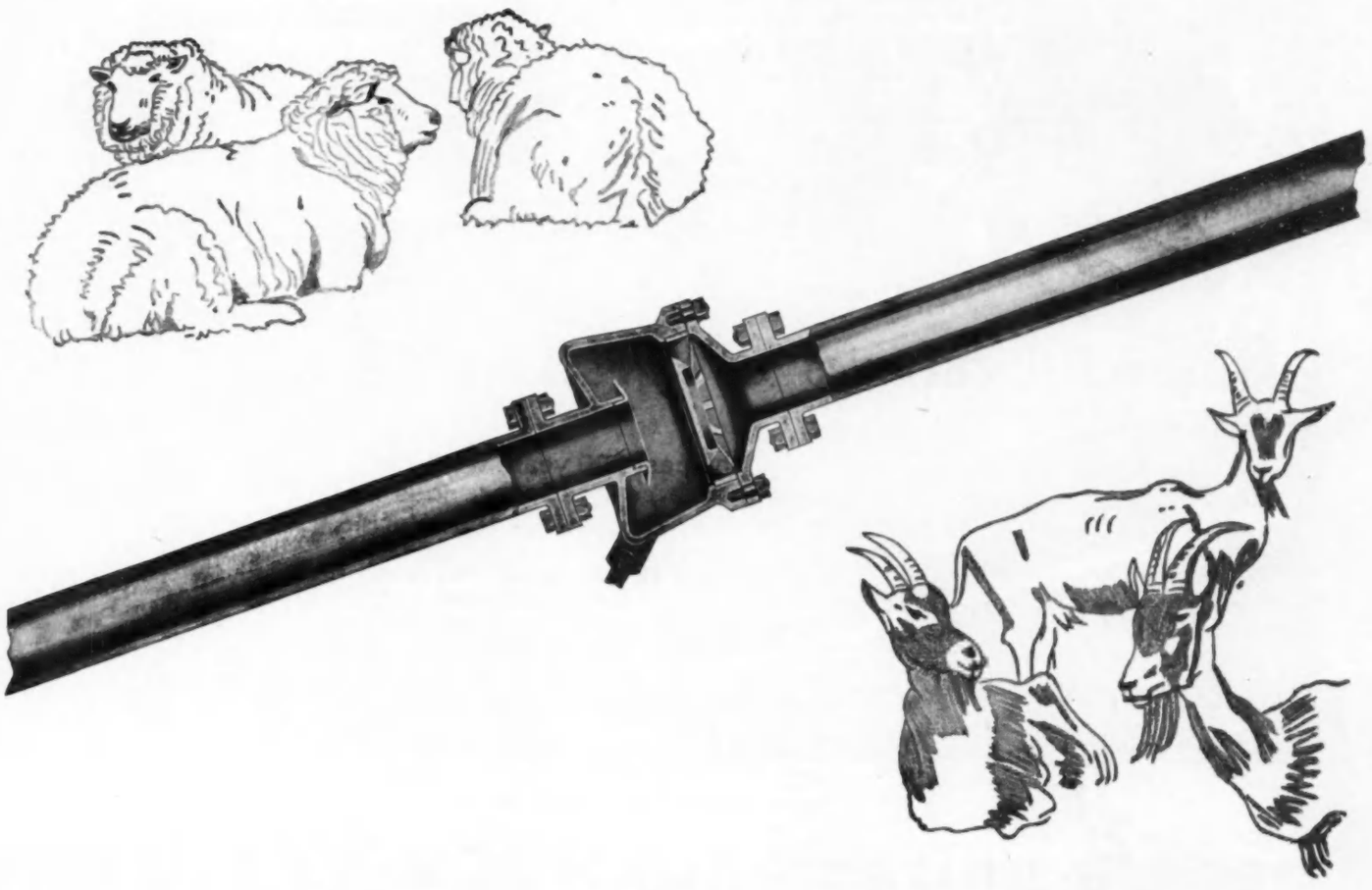

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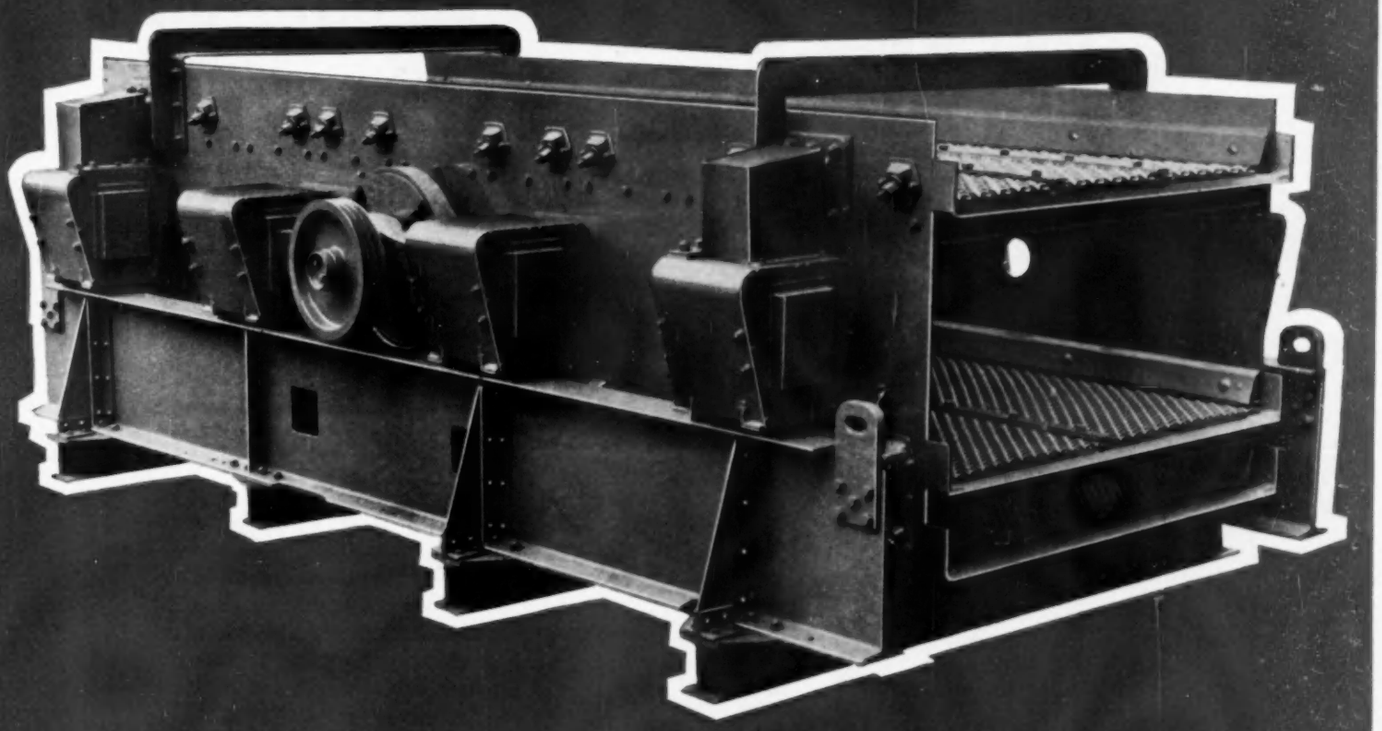

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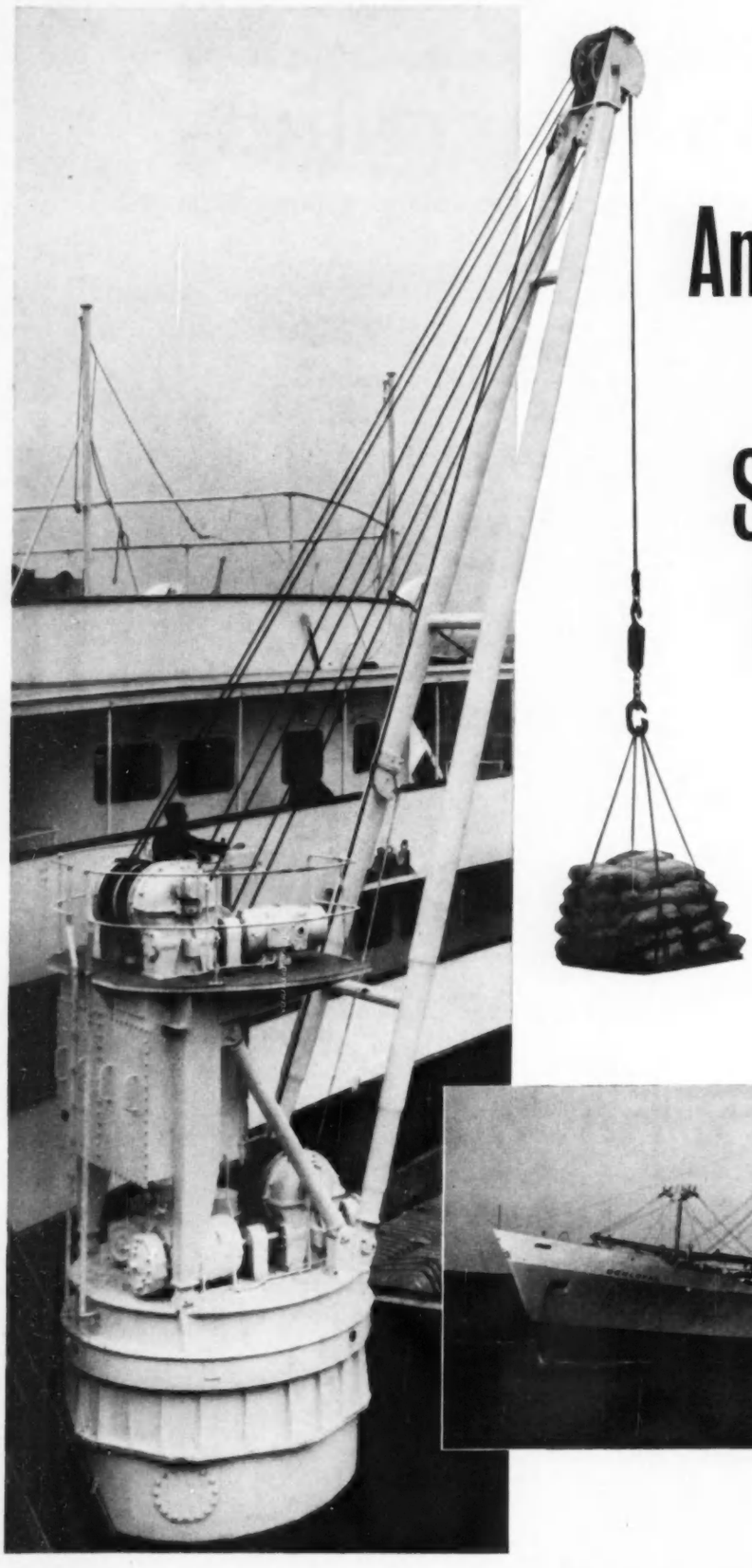

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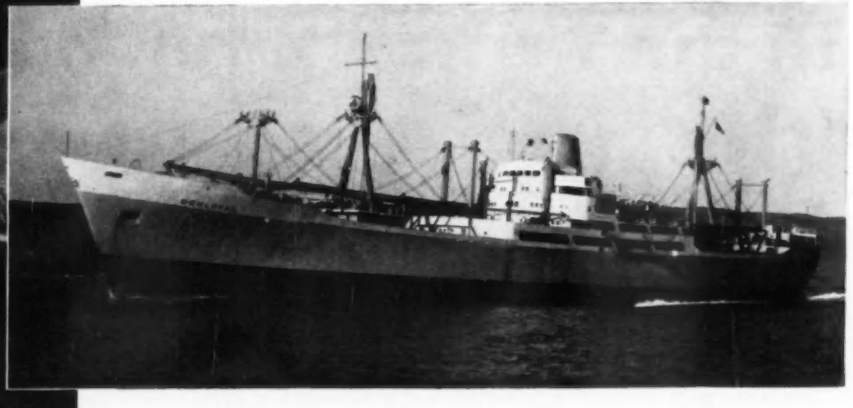

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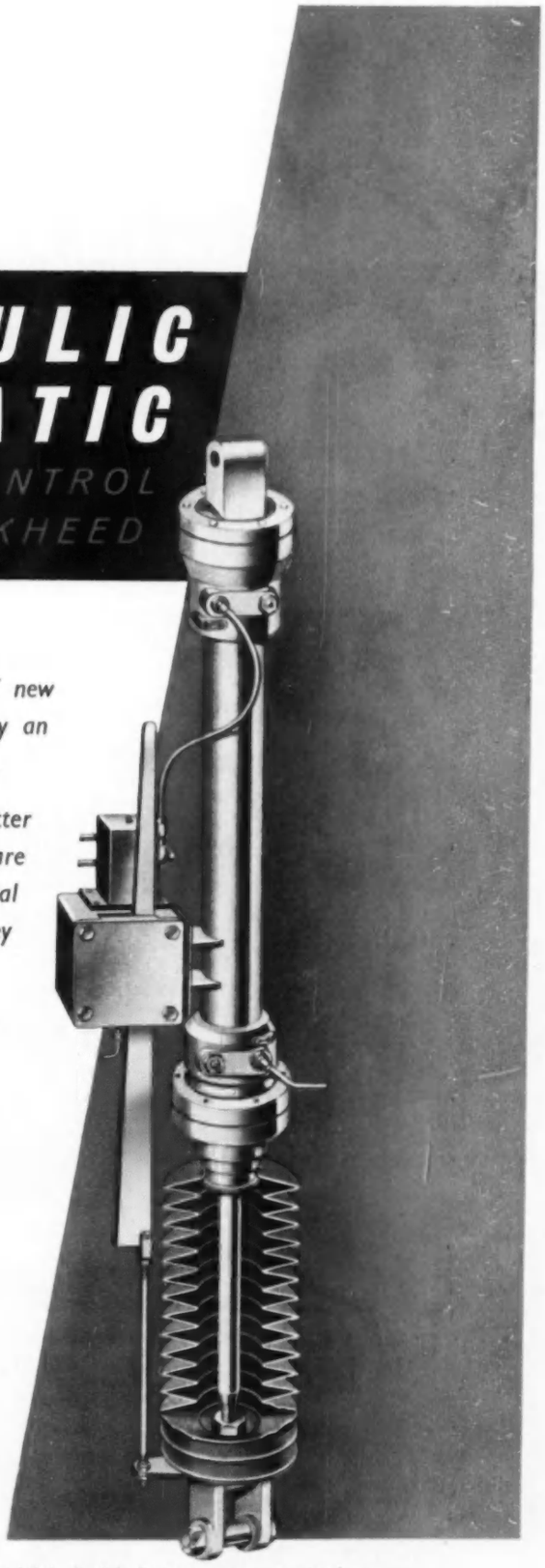

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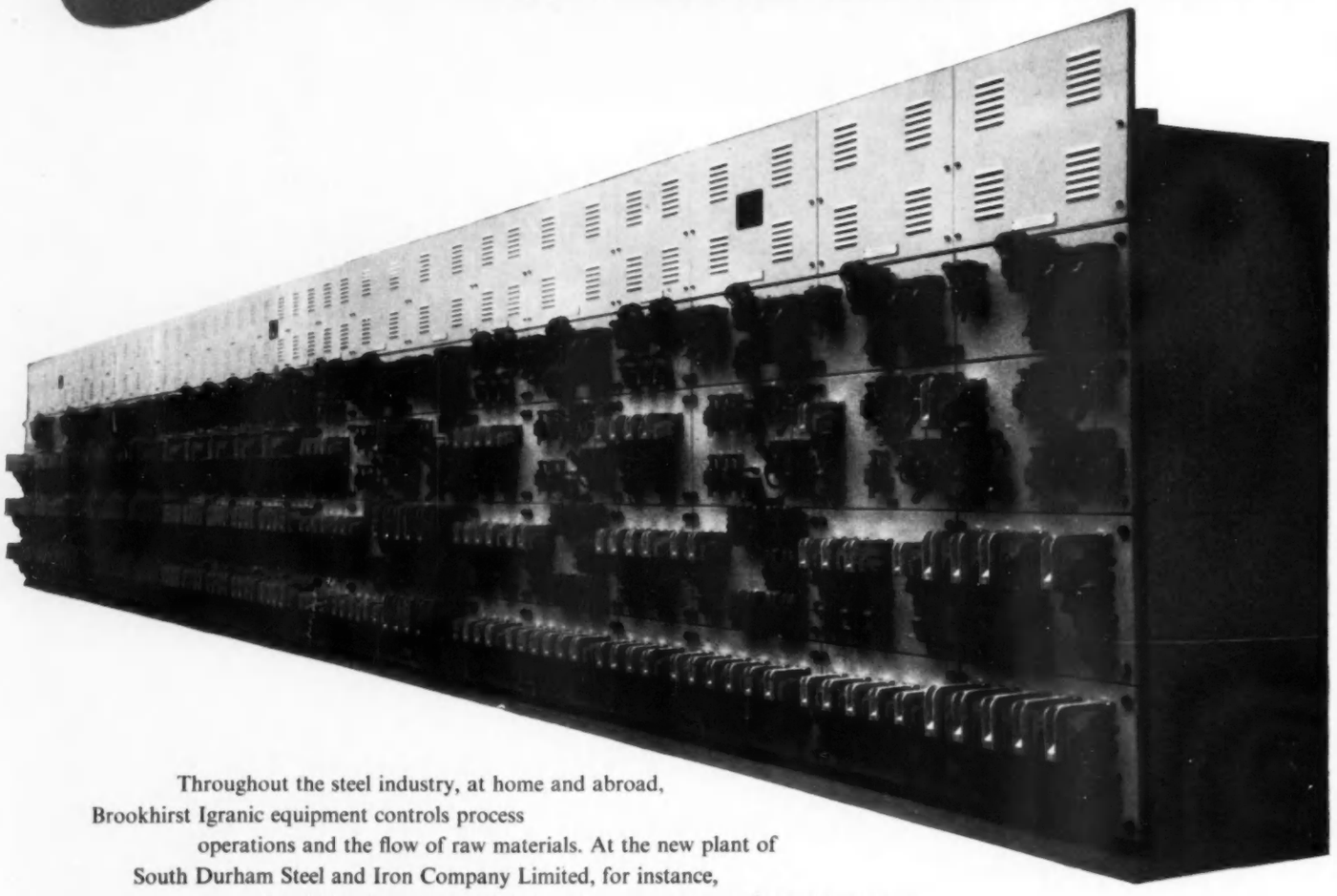

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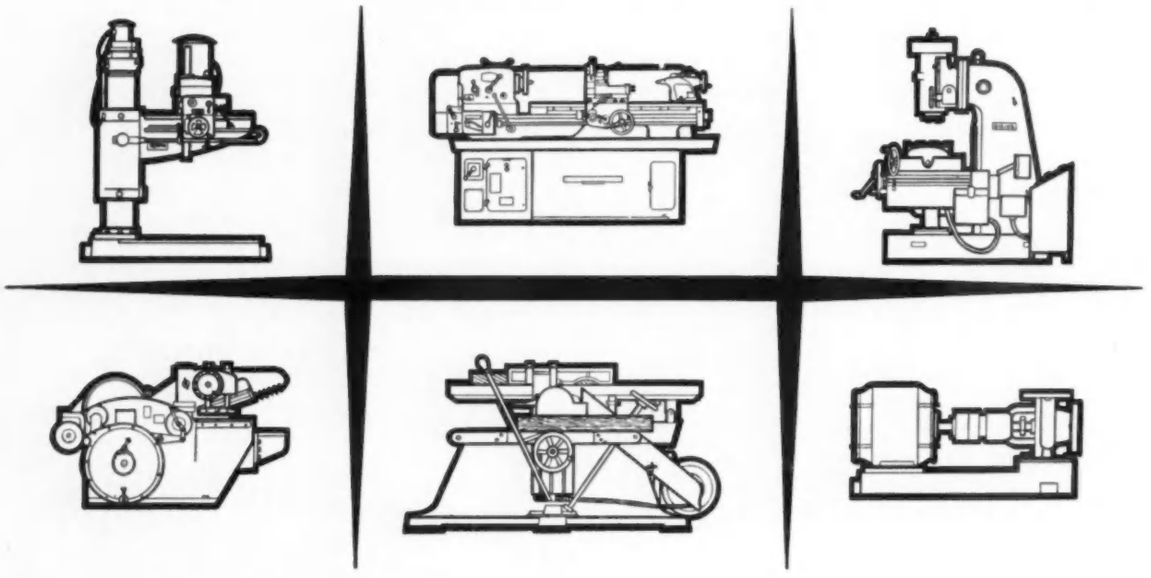

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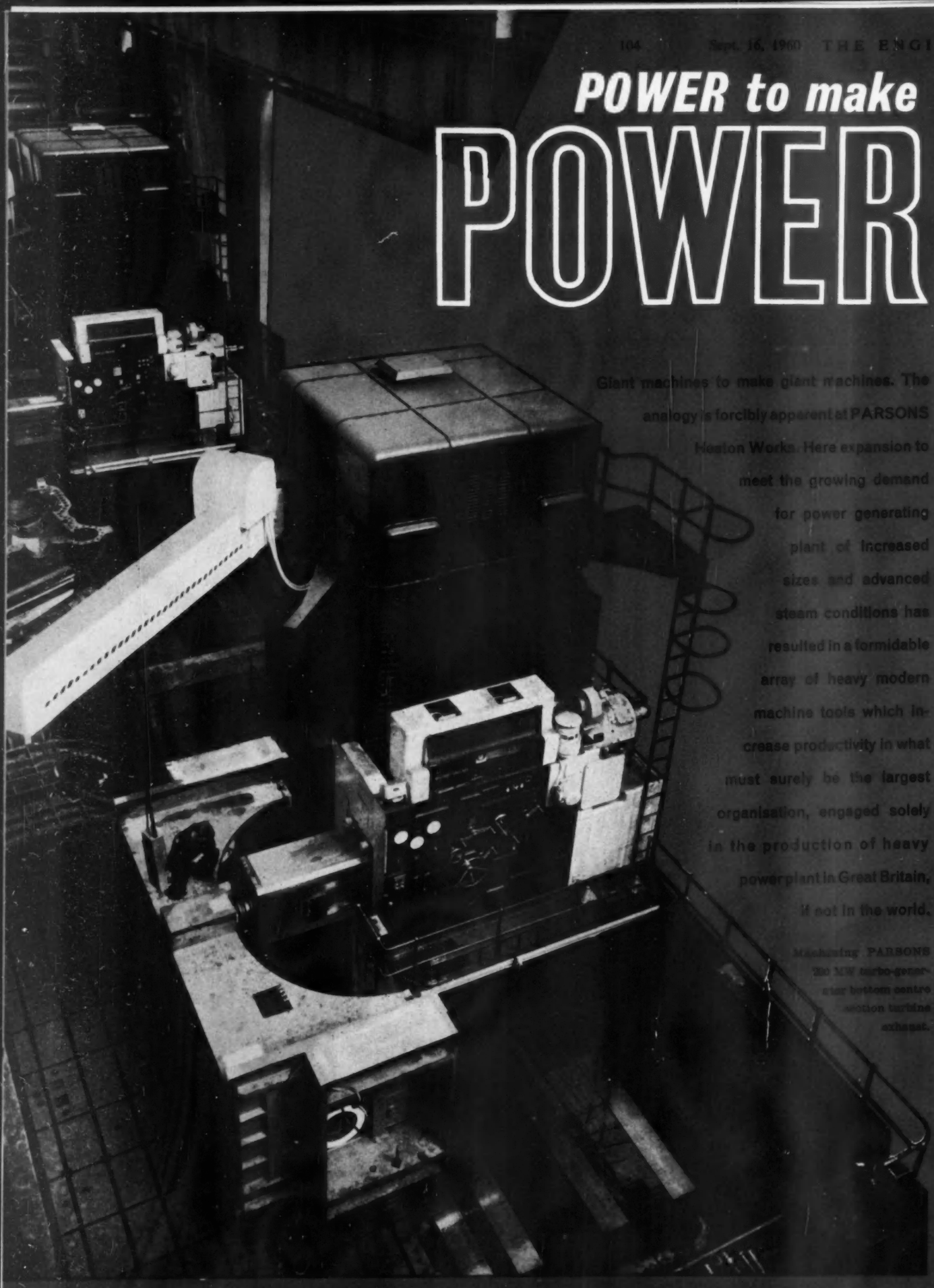

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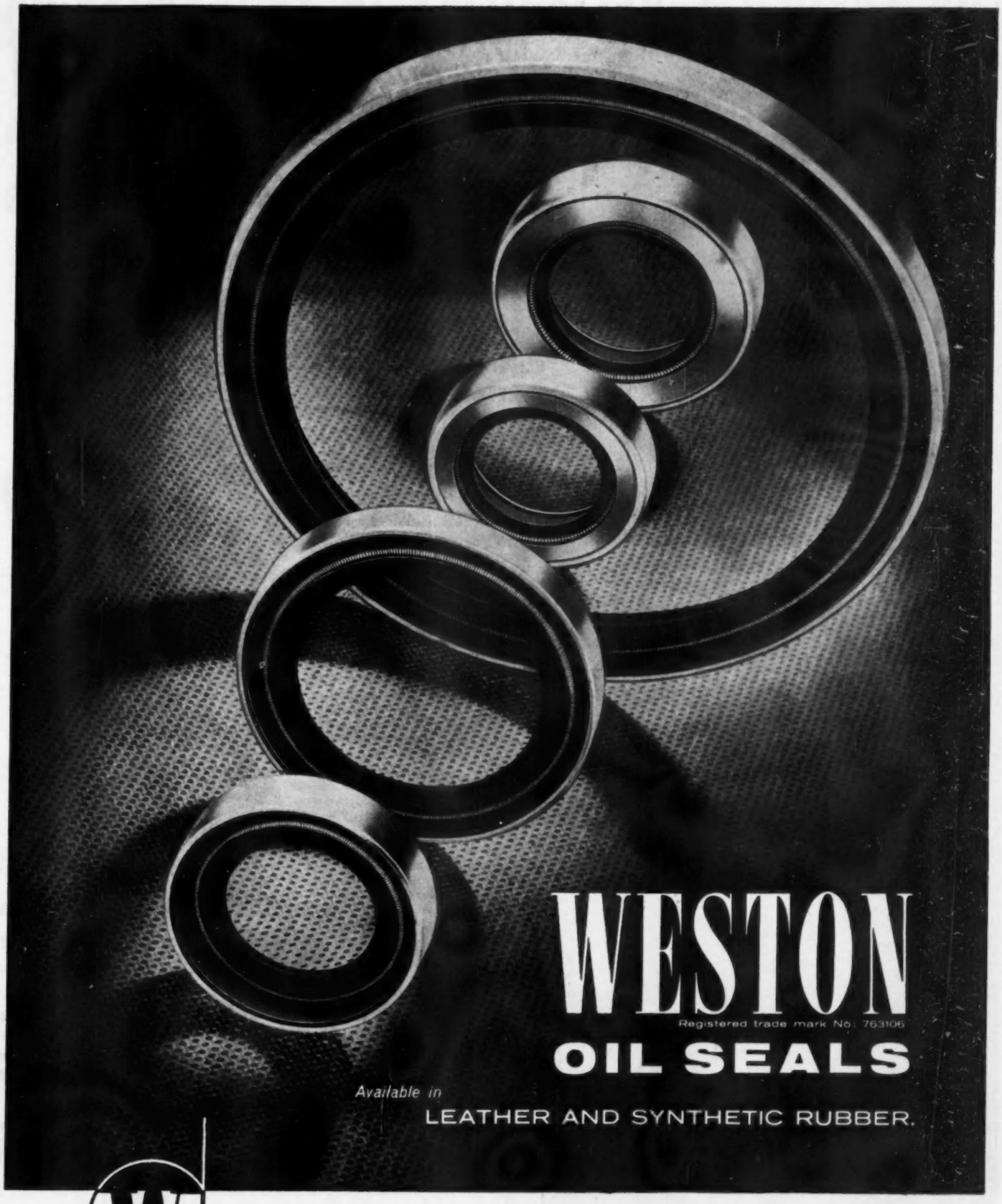

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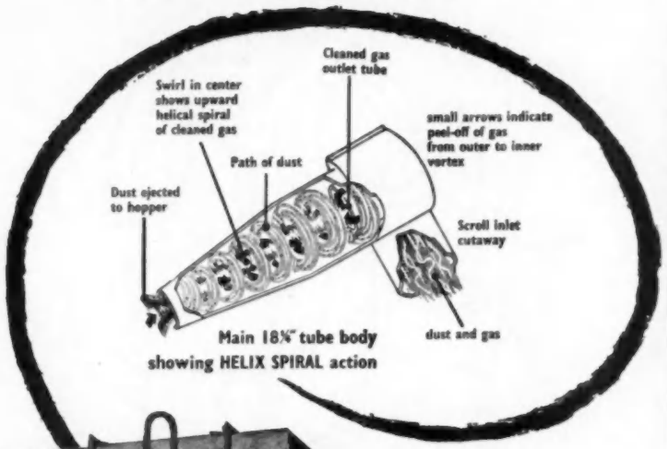
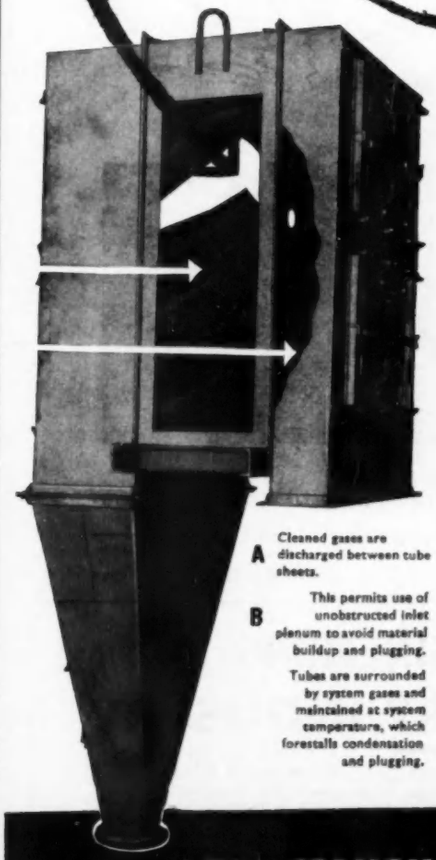

Cleaned gas outlet tube
Swirl in center shows upward helical spiral of cleaned gas
small arrows indicate peel-off of gas from outer to inner vortex
Path of dust
Dust ejected to hopper
Scroll inlet cutaway
dust and gas
Main 18¾" tube body showing HELIX SPIRAL action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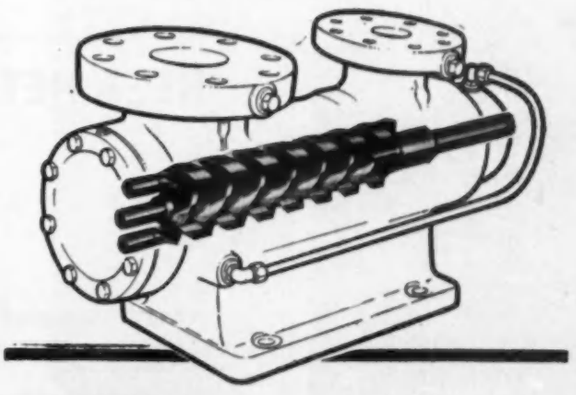

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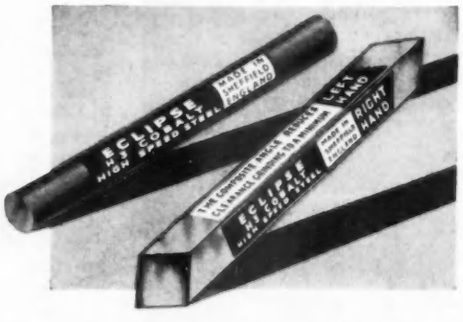

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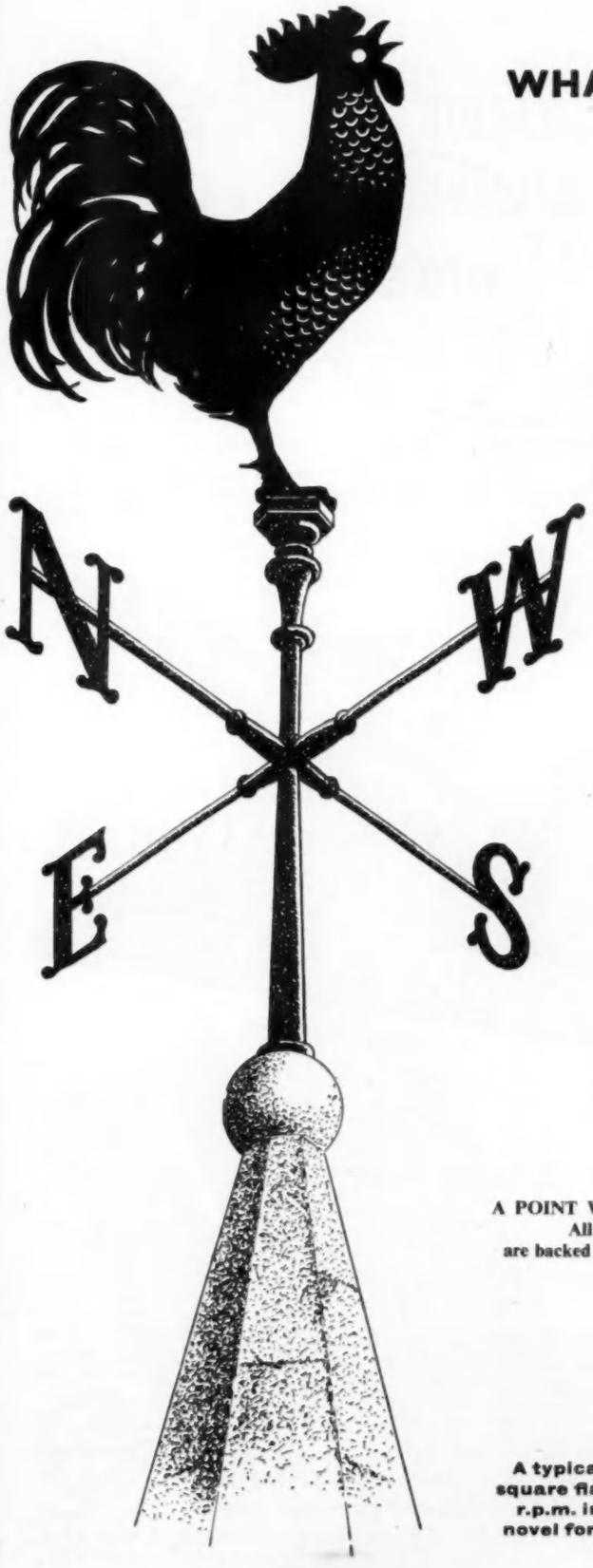

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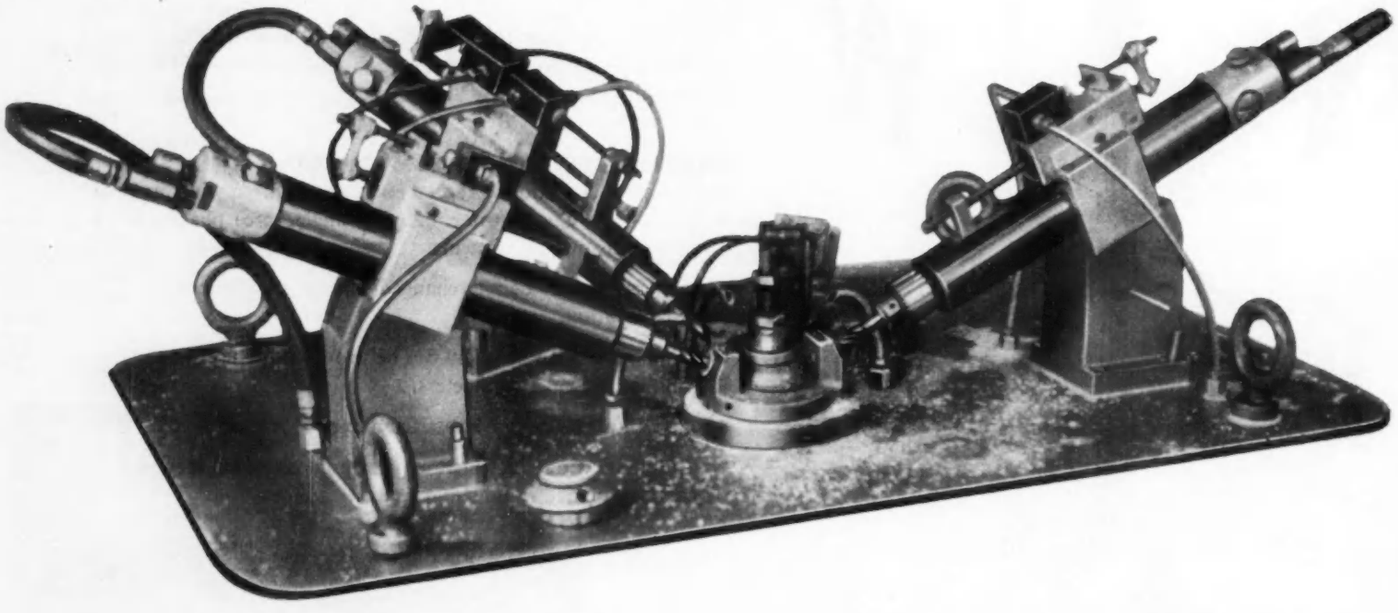

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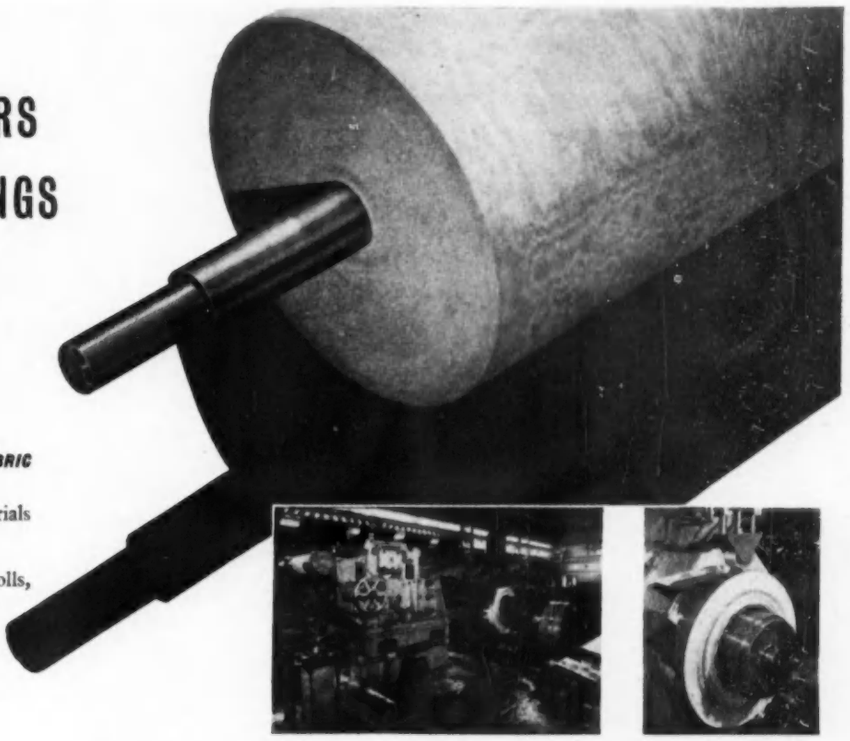

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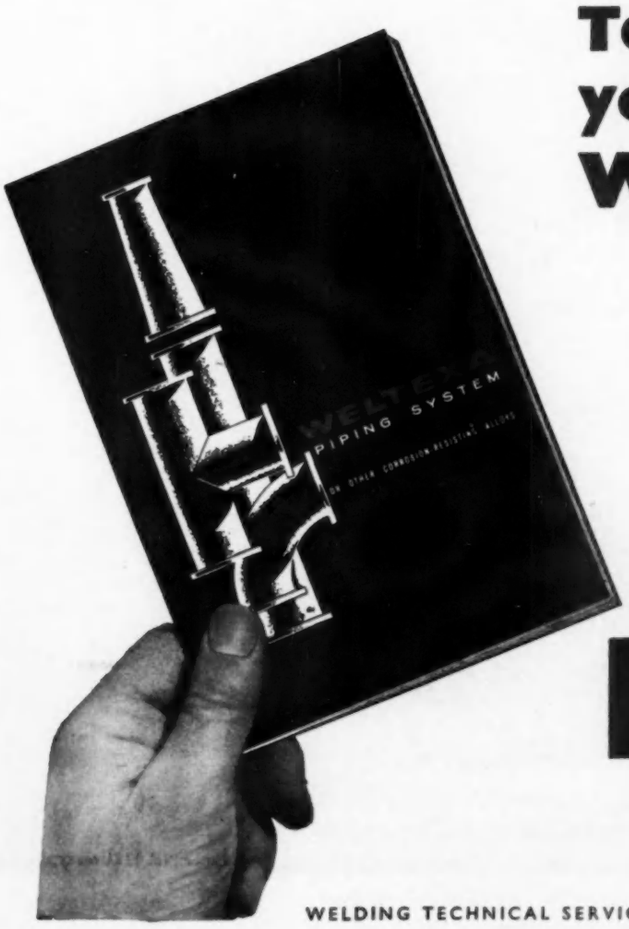

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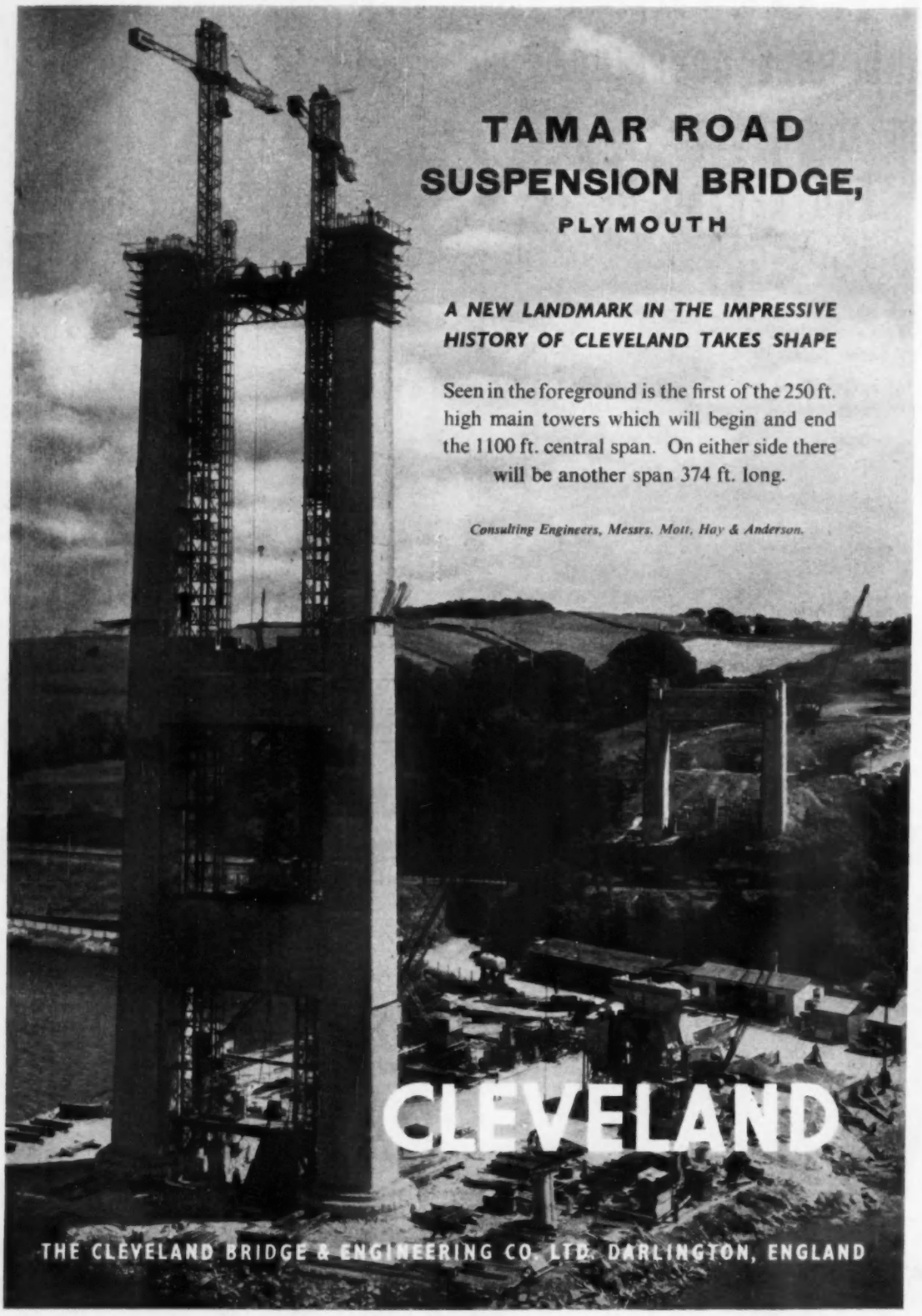
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A NEW LANDMARK IN THE IMPRESSIVE HISTORY OF CLEVELAND TAKES SHAPE
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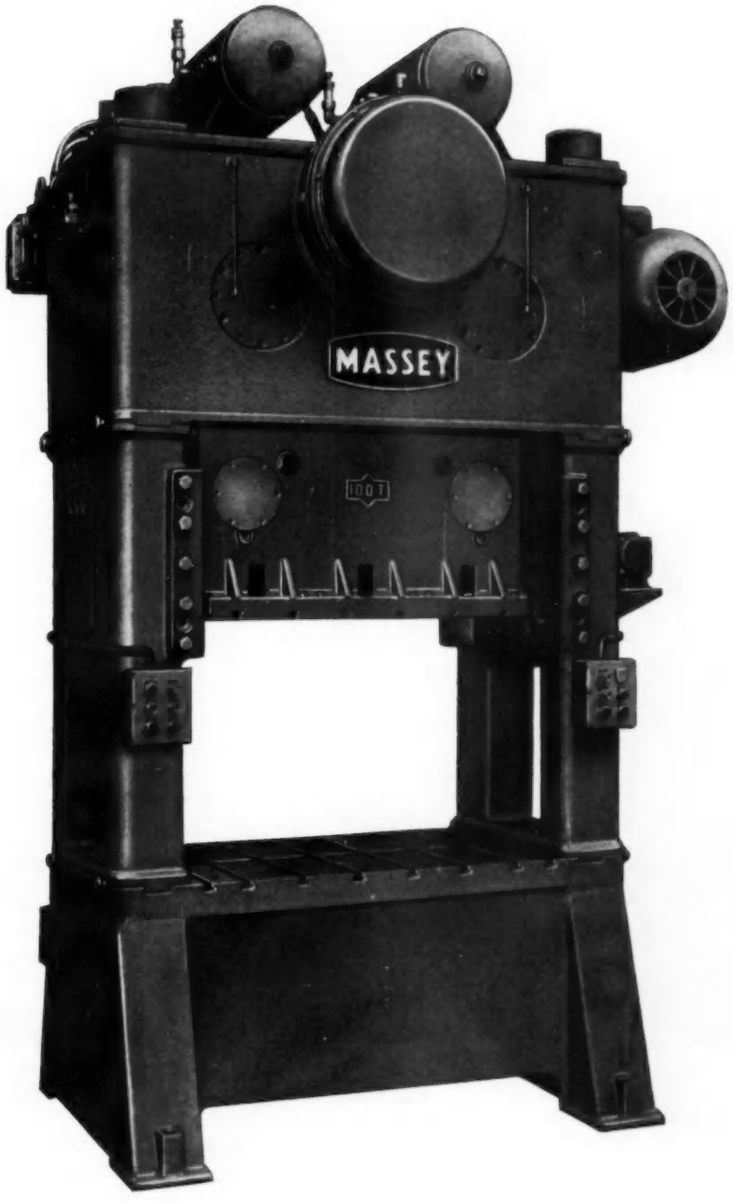
PRESSES for trimming, setting, etc.



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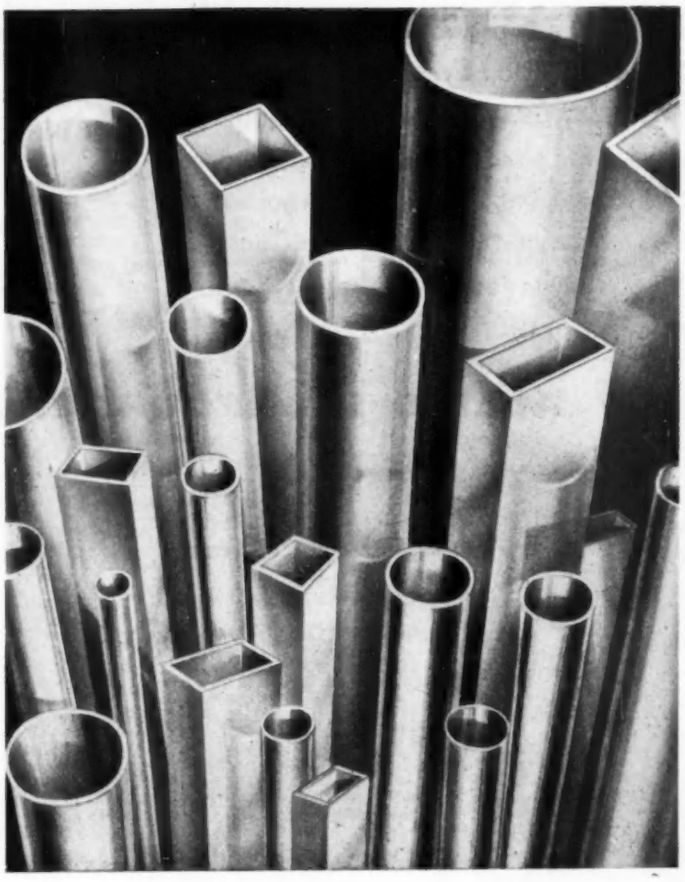

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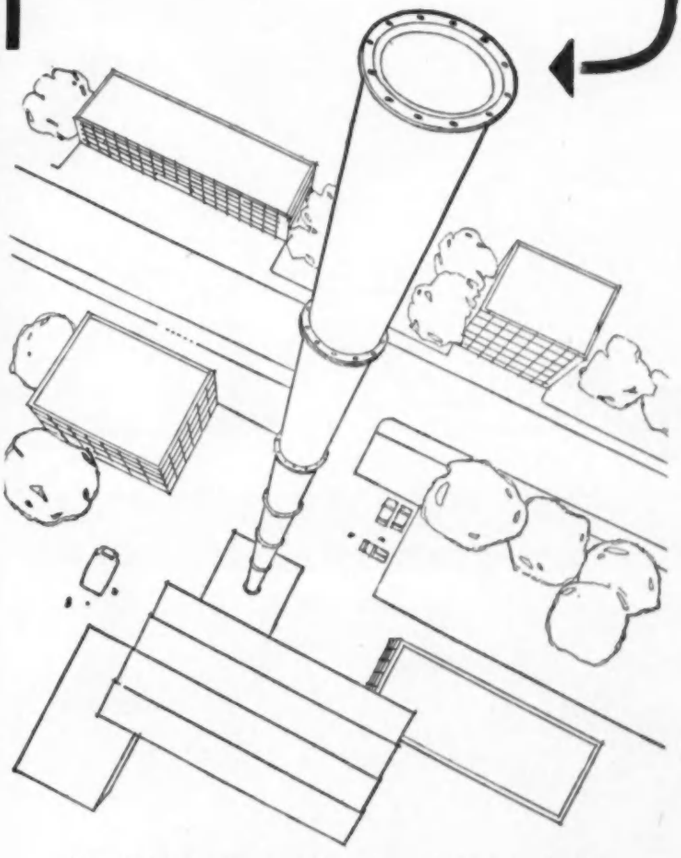

- Maintains inner surface above dew point of gases and stops condensation.
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A full description of this chimney appeared Page 322 in "The Engineer" dated 19 August 1960

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PRECISION TORQUE SPANNERS

Sixteen models provide for loads up to 850 lbs/ft
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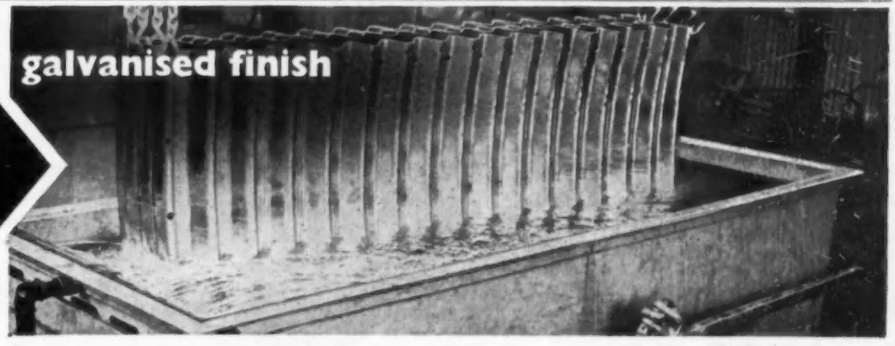

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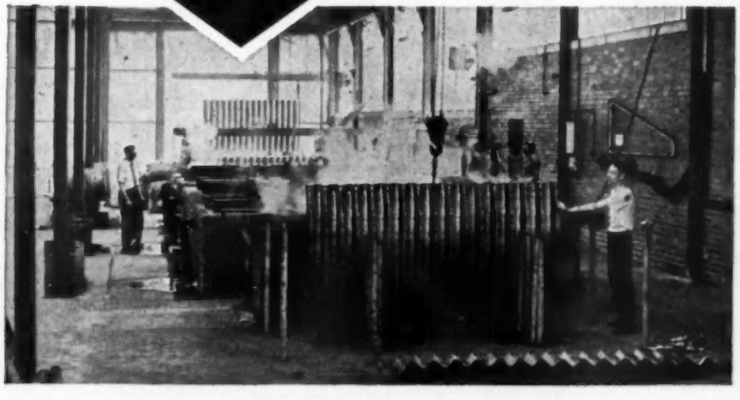

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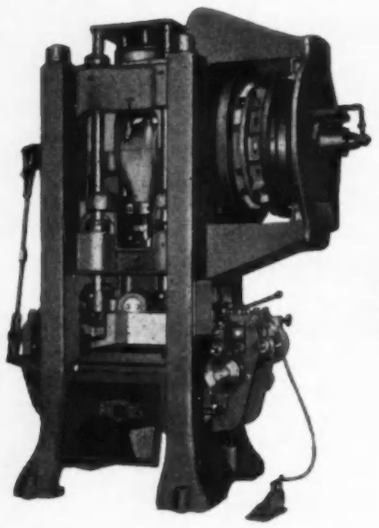
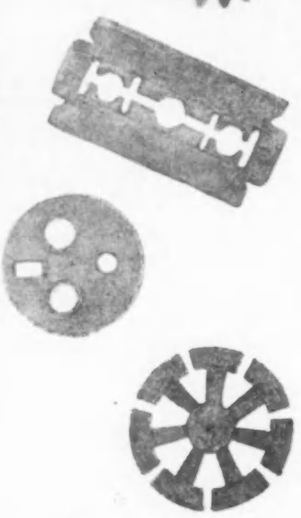
...But if you want a job that may well be worth its weight in gold you ought to have a look at our automatic projection blanking presses. Revolutionary design revolutionises tool life. The top die never enters the bottom die. The blank is projected — not cut. There can be no half stampings. Speed, 120-450 strokes per min. Quadruple bar slides. Prestressed body. No glittering gimmicks that turn out to be fool's gold. Our designs are hall-marked by 136 years of knowing how to engineer presses, the kind of designs you can get only when you've been at it long enough to think with your head in the clouds and still keep your feet solidly on the shop floor.





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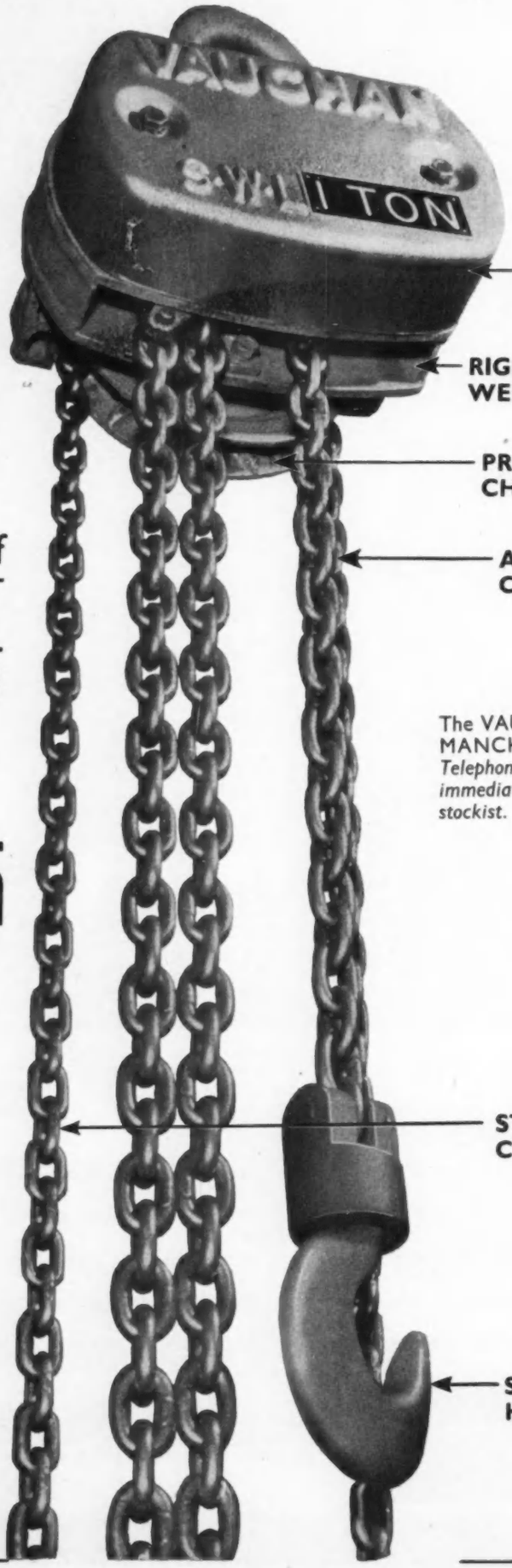

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There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

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Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

AUSTRALIA

THE UNIVERSITY OF NEW SOUTH WALES

WARDEN WOLLONGONG UNIVERSITY COLLEGE

The University invites applications for appointment to the position of WARDEN of the WOLLONGONG UNIVERSITY COLLEGE.

Salary : £A4263 per annum.

The Warden will, under the Vice-Chancellor, be charged with the duty of managing and supervising the administrative, financial and other activities of the University College.

He will be required to consult with and advise the Professorial Board of which he will be a member and with the faculties, committees and other academic organisations which will be concerned with the College.

Applicants should possess high academic qualifications in one or more of the fields of chemistry, physics, mathematics, mechanical engineering or metallurgy, and should have had substantial administrative experience, preferably, though not necessarily, in a University or similar academic institution.

Subject to satisfactory medical examination, the successful applicant will be eligible to join the superannuation scheme which provides a maximum pension of £A2184 per annum, and he would be eligible for six months' study leave on full salary after three years of service, or twelve months after six years of service.

The University reserves the right to fill the position by invitation.

First class ship fares to Sydney of the appointee and his family will be paid.

Four copies of applications (typed), together with the names of three referees and a recent photograph of the applicant, should be lodged with the Agent General for New South Wales, 56-57 Strand, London, W.C.2, and a copy forwarded by airmail in an envelope marked "University Appointment" to the Bursar, The University of New South Wales, Box 1, Post Office, Kensington, New South Wales, Australia, before 31st October, 1960. E5946

IMPERIAL COLLEGE OF SCIENCE & TECHNOLOGY

LECTURER IN FLUID MECHANICS

Applications are invited from engineers or others interested in Fluid Motion and its technical applications. This post, with salary scale, £1050 by £50 to £1400 by £75 to £1550 (bar) by £75 to £1850 per annum, plus £60 per annum London Allowance, F.S.S.U. membership and Family Allowances, offers ample opportunity for individual experimental research in a new and well equipped laboratory. Candidates with practical experience and good honours degree should apply to Professor C. M. White, Imperial College of Science and Technology, London, S.W.7. E5928

DEPARTMENT OF MAIN ROADS

NEW SOUTH WALES, AUSTRALIA

CIVIL ENGINEERS

Applications are invited from graduates (or undergraduates in their final year) in Civil Engineering of a recognised British or Irish University for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges.

On appointment, applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges, or on main road construction and maintenance either in the Metropolitan Area or the country.

Commencing salary according to qualifications and experience will be within the range £A1185 to £A1410 per annum, with annual progression, subject to technical competence to £A2095 per annum. Appointees will be eligible to contribute to the State Superannuation Fund after six months.

Appointee's full fair from England to Australia will be met by the Department, subject to a three years' service guarantee bond being completed. Appointment will be subject to passing a medical examination and preference will be given to applicants not more than 30 years of age.

Applications should be made on forms obtainable from the Agent General for New South Wales, 56 Strand, London, W.C.2. Please quote the number 44/31 in your letter. E5973

PUBLIC APPOINTMENTS

UNIVERSITY OF QUEENSLAND

SENIOR LECTURER IN ELECTRICAL ENGINEERING

Applications are invited for the above-mentioned position. Applicants must hold an Honours Degree and preferably a higher degree in Electrical Engineering with specialisation in electronics.

The duties will include lectures in advanced circuit and field theory and arrangement of the appropriate practical work.

The salary for a Senior Lecturer is £A2520 to £A2870 p.a.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close, in Australia and London, on 15th October, 1960. E5965

LONDON COUNTY COUNCIL

WANDSWORTH TECHNICAL COLLEGE

HEAD OF ELECTRICAL ENGINEERING DEPARTMENT

Required January, 1961 HEAD OF ELECTRICAL ENGINEERING DEPARTMENT comprising part-time day and evening classes in Electrical Engineering to H.N.C. and Endorsement standards, also extensive C. & G. and trade courses ; should hold degree in Electrical Engineering and Corporate Membership of an Engineering Institution ; industrial and technical teaching experience essential.

Salary : Burnham Grade 3, Head of Department, £1800 by £50 to £1950, plus London Allowance.

Full details and application form from Secretary at College, Wandsworth High Street, S.W.18, returnable by 5 October. Please quote ref. : (FE3A/E/2302/9). E5875

ESSEX RIVER BOARD

APPOINTMENTS

Applications are invited for the following permanent posts which are subject to the Local Government Superannuation Acts 1937-1953 :

1. SENIOR CIVIL ENGINEER A.P.T. V (£1220 to £1375).
2. SENIOR CIVIL ENGINEER A.P.T. IV (£1065 to £1220).
3. CIVIL ENGINEERING ASSISTANT, salary between A.P.T. I (£610 to £765) and Special Grade (£785 to £1070) according to qualifications and experience.

These posts are at the Board's Head Office at Chelmsford on design work in connection with sea defence and land drainage schemes.

Applicants should be Chartered Civil Engineers experienced in sea defences works and/or design and investigation of land drainage schemes.

A car allowance on the Essential User scale will be payable for posts 1 and 2.

Applications giving details of age, education and previous experience, and the names of three referees with a knowledge of the applicant's technical experience, should be submitted to the Engineer to the Board at the address given below by the 3rd October, 1960.

W. J. S. BEW,
Clerk of the Board.

Rivers House,
New Writtle Street,
Chelmsford, Essex.
7th September, 1960. E5934

GOVERNMENT OF HONG KONG

ELECTRICAL/MECHANICAL ENGINEER, PUBLIC WORKS DEPARTMENT

Duties comprise the design, estimation, installation, operation and maintenance of air conditioning installations in large buildings including refrigeration plant.

Permanent and pensionable or contract/gratuity appointment. Salary according to experience within the range £1650 to £2865. Quarters at low rent. Free passages. Generous leave.

Candidates must be under 45 years and A.M.I.E.E. or A.M.I.Mech.E. with at least 3 years' post qualification experience in the refrigeration industry.

Write Director of Recruitment, Colonial Office, London, S.W.1, giving full names, age, qualifications and experience, quoting BCD 112/51/033/D4. E5936

PUBLIC APPOINTMENTS

AIR MINISTRY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary—£805 at 25 to £1095 at 34 or over, thereafter rising to maximum £1260 with increase for London and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. 5 day week with 4 weeks 2 days leave a year initially. Special allowance in addition to salary during overseas service. Qualifications and experience :

(i) (a) University degree or equivalent diploma in electrical and/or mechanical engineering with at least 2 years apprenticeship ; or
(b) Graduate or corporate member of I.E.E. with at least 3 years apprenticeship ; or
(c) Graduate or corporate member of I.Mech.E. appreciable electrical engineering experience with at least 3 years apprenticeship ; and
(ii) Have been employed for minimum of 2 years with well established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects between ages of 25 and 45. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.158/OA. E5671

CITY OF PLYMOUTH

APPOINTMENTS

Applications are invited for the following appointments :

1. SENIOR ENGINEER, Scale "B" (£1315 to £1485).
2. SENIOR ASSISTANT ENGINEER, Grade A.P.T.V. (£1220 to £1375).
3. DRAUGHTSMAN / SURVEYOR, Miscellaneous Grade V (£650 to £715).

Applicants for 1 and 2 must be professionally qualified and have had a good experience in the design and construction of major roads and concrete bridges.

Applicants for 3 should be neat and quick draughtsmen with experience in carrying out surveys.

Age limit for these appointments 40 (or 45 if already serving with a Local Authority). The appointments are subject to medical examination and successful applicants will be required to contribute to the Superannuation Fund.

Housing accommodation if required will be made available and part of removal expenses refunded.

Applications on forms obtainable from me are returnable by the 3rd October, 1960.

J. ACKROYD,
City Engineer and Surveyor.

The Guildhall,
Plymouth. E5923

INLAND REVENUE VALUATION OFFICE

ENGLAND AND WALES

APPOINTMENTS

Pensionable posts in offices in England and Wales and in Scotland for qualified men and women at least 25 on 1st October, 1960. Vacancies are in District (Revenue and Compensation) and Area (Rating) offices and include posts for valuation of minerals, plant and machinery, and licensed property. Vacancies in Scotland are in District (Revenue and Compensation) offices only. Posts for valuation of minerals in 2nd or 3rd Class ; all others in 3rd Class. Qualifications : (a) Final examination of R.I.C.S., C.A. and E.A.I., or C.I.A.S., or B.A. (Cantab. or B.Sc. (Lond.) in Estate Management. At least four years' professional (or mining, for valuation of mineral posts) experience. For Scottish posts experience in Scotland desirable, and qualifying examination preferably based on Scottish syllabus. For valuation of mineral posts, 1st Class Certificate of Competency (Mine Managers) acceptable as professional qualification. Starting salary (men, London) : 3rd Class from £830 (25) to £1205 (36 or over) ; scale maximum £1300. 2nd Class scale £1325 to £1835. Promotion prospects. Write Civil Service Commission, Burlington Gardens, London, W.1, for application form quoting 148-149/60. Closing date 18th October, 1960. E5939

PUBLIC APPOINTMENTS

CITY OF BIRMINGHAM PUBLIC WORKS DEPARTMENT

MECHANICAL AND ELECTRICAL SECTION

Applications are invited for the following posts in the Design Office.

(a) SENIOR ENGINEERS (Heating and Ventilating), A.P.T. IV (£1065 to £1220 p.a.).

(b) ASSISTANT ENGINEER (Heating and Ventilating), Special Grade (£785 to £1070 p.a.).

Applicants must be Associate Members of the Institution of Heating and Ventilating Engineers, or hold the Higher National Certificate in Mechanical or Electrical Engineering (with five years' experience).

Duties undertaken in this office, include the design of mechanical, electrical and heating services and installations in Civic Buildings, municipal offices, multi-storey flats and other dwellings, car parking garages, fire and police stations, schools, baths, salvage destructor plants, pumping stations, etc.

Applicants must have had experience in the design, specification and supervision of contracts associated with the above work.

The appointments are permanent, superannuable, subject to a medical examination and terminable by one month's notice on either side.

Applications endorsed with the heading of the post applied for, stating qualifications, age and experience, together with the names of two persons to whom reference may be made, should reach the undersigned not later than 1st October, 1960.

Canvassing disqualifies.

HERBERT J. MANZONI,
City Engineer and Surveyor.

Civic Centre,
Birmingham, 1.
5th September, 1960. E5931

METROPOLITAN WATER, SEWERAGE AND DRAINAGE BOARD OF NEW SOUTH WALES

AUSTRALIA

ENGINEERS

Applications are invited from graduates or diplomates (preferably under 30 years of age) in Engineering for appointment to the Engineering staff of the Metropolitan Water, Sewerage and Drainage Board of New South Wales. Because of accommodation difficulties, vacancies exist only for single men and married men without children.

Minimum commencing salary £A1250 p.a. for a diplomate and £A1368 p.a. for a graduate, with incremental progression, subject to satisfactory service, to £A2040 p.a. Progression beyond this rate is by appointment as vacancies arise.

The main requirement is for Civil Engineers, who have just completed training but consideration will also be given to those with some experience and to graduates and diplomates in Mechanical, Electrical and Chemical Engineering.

Appointees will be employed on the investigation, design, construction or maintenance of water, sewerage and storm-water drainage projects in the Sydney or Wollongong areas. No country service is involved.

Superannuation Scheme. Good leave conditions.

Successful applicants will be nominated for travel under the Assisted Passage Scheme. The cost of the passage is £10 per adult.

For further particulars and application forms, please write to Agent General for New South Wales, 56 Strand, London, W.C.2, quoting the number 44/97 in your letter. E5959

EAST SURREY WATER COMPANY

ENGINEERING ASSISTANT

The Company requires the services of a qualified CIVIL ENGINEERING ASSISTANT on the permanent staff to assist initially with a £750,000 capital works programme. The Company at present supplies an area of 280 square miles with 15 m.g.d.

Housing accommodation will be provided, if required, and removal expenses paid.

Starting salary will be between £1000 and £1250 per annum, according to experience, with pension rights.

Applications, giving details of age, education, qualifications and experience, should be received by the undersigned by the 26th September, 1960.

G. M. SWALES,
B.Eng., A.M.I.C.E., M.I.W.E.
Chief Engineer.

London Road,
Redhill, Surrey. E5855

Classified Advts. continued on page 124

PUBLIC APPOINTMENTS

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Royal Naval Scientific Service require SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS in establishments in following locations: London Area, Haslemere, Baldock, Poole, Cheltenham, Portland, Portsmouth.

Applications invited from graduates and post-graduate research workers with the following interests :

PHYSICS (classical, mathematical and electronic) ; ELECTRICAL ENGINEERING (electronic, telecommunications and radio) ; MATHEMATICS (pure and applied) ; HYDRODYNAMICS, MECHANICAL ENGINEERING (including servo-mechanisms, gyroscopes and welding development) ; CHEMISTRY (ceramics with solid state properties).

Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Honours Degrees or equivalent qualifications. S.S.Os must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men) S.S.O. £1330 to £1640; S.O. £730 to £1205 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Order No. A.359/OA.

E5754

CHESHIRE RIVER BOARD

BIRKET AND FENDER IMPROVEMENT SCHEME

ASSISTANT RESIDENT ENGINEER

Applications are invited for the temporary appointment of an ASSISTANT RESIDENT ENGINEER on the above scheme. The Works include the construction of a flood relief Pumping Station in a reclaimed portion of the Morpeth Branch Dock, Birkenhead, diversionary works to the Great Culvert, a discharge culvert constructed in tunnel in the dock wall and the erection of pumping plant.

The Assistant Resident Engineer will be required to supervise underwater work carried out by divers and will be required to pass a medical examination for diving up to a maximum depth in water of 40-ft.

Salary £1200 per annum for the duration of the appointment which is expected to be about 18 months, commencing December 1960

Conditions of Service as Parts, 2, 4 and 5 only of the Scheme of Conditions of Service issued by the National Joint Council for Local Authorities, Administrative, Professional Technical and Clerical Staffs.

Applications endorsed "Assistant Resident Engineer" giving full particulars of age, qualifications, experience and also the names of two persons to whom reference can be made should reach the undersigned not later than 3rd October, 1960.

SANDFORD FAWCETT & PARTNERS,
53 Victoria Street, Consulting Civil Engineers.
Westminster, S.W.1. E5883

GOVERNMENT OF UGANDA

FACTORIES INSPECTOR (ELECTRICAL)

FACTORIES INSPECTOR (ELECTRICAL), male, aged 25-35, required to advise the Chief Factories Inspector and Factories Inspectors on Electrical Safety in Factories and other industrial places, and to inspect Factories, &c., for enforcement of safety rules in electrical matters. Degree in Electrical Engineering or equivalent (e.g. Graduate Membership of Institute of Electrical Engineering and subsequent completion of Recognised Graduate Apprenticeship in Electrical Engineering) essential. Experience of the investigation and prevention of Electrical accidents and experience of United Kingdom Electricity Regulations made under the Factories Acts desirable. Post permanent and pensionable or on contract/resettlement grant terms if preferred. Salary at appropriate point in scale £939 to £1863 inclusive. Quarters at low rental. Free passages and medical attendance. Education allowance (in respect of children educated in secondary schools outside Uganda). Low income tax. Generous home leave. Further particulars and application forms from Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD 132/9/02/D4. Candidates should state their full names when applying. E5862

CIVIL SERVICE COMMISSION

MECHANICAL AND ELECTRICAL ENGINEERS

Pensionable posts for men and women normally under 35 on 1st September, 1960. Applicants must normally have degree or Dip. Tech. in engineering or physics or have passed examinations necessary for A.M.I.Mech.E., A.M.I.E.E., A.F.R.Ae.Soc., &c. Exceptionally, evidence of high professional attainment acceptable in lieu. Practical training and experience required but untrained graduates acceptable for some posts. Men's starting salary (London) from £830 lower if under 25) to £1125. Maximum £1300. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting S/851/60. Closing date 13th October, 1960. Earlier applicants may be interviewed before that date. E5943

PUBLIC APPOINTMENTS

MINISTRY OF AVIATION

LONDON

CHEMIST, PHYSICIST OR ENGINEER

Ministry of Aviation requires in London a CHEMIST, PHYSICIST or ENGINEER to assist senior officers on safety matters connected with ionising radiation hazards and to inspect establishments. Considerable travelling involved. Qualifications: Hons. degree in chemistry, chemial engineering, physics, A.R.I.C., A.M.I.Chem.E., A.I.P., or equivalent or have served recognised engineering apprenticeship and A.M.I.Mech.E., A.M.I.E.E. or A.M.I.C.E. Knowledge of radioactive materials, apparatus and appropriate safety devices required. Selected candidate will undergo period of training. Salary : £850 (age 25) to £1260. Opportunities for establishment. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting reference F.154/OA. Closing date 29th September, 1960. E5941

PUBLIC APPOINTMENTS

CUSTOMS AND EXCISE DEPARTMENT

LONDON

ASSISTANT SUPERINTENDENT ENGINEER

Pensionable post in London for man preferably under 46 to assist in the design, construction, and maintenance of the Customs fleet. Qualifications : Extra First Class Certificate of Competency endorsed for steam and motor ; or First Class Certificate of Competency endorsed for steam or motor together with an advanced technical qualification in engineering or naval architecture (e.g. degree, H.N.C., A.M.I.Mech.E., A.M.I.Mar.E.). Sound knowledge of design and construction of small vessels and experience of supervising repairs to ships and their machinery essential. Salary scale £1115 to £1375. Excellent promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting S/5198/60. Closing date 3rd November, 1960. E5940

CITY OF LIVERPOOL

City Engineer and Surveyor's Department

Applications are invited for the appointment of :

ASSISTANT CITY ENGINEER (Mechanical)—Salary £1655-£2085 per annum (J.N.C. Scales E/F).

Applicants should be Associate Members of the Institution of Mechanical Engineers and have had a good general engineering background, together with experience of works organisation and management. The person appointed will be responsible for the organisation and control of the mechanical engineering drawing office and central engineering workshops and for maintaining a large fleet of vehicles, civil engineering plant, sewage pumps and other mechanical equipment.

The appointment is superannuable and subject to the Standing Orders of the City Council. Canvassing disqualifies.

Further details and application form, returnable by 1st October, 1960, from the City Engineer and Surveyor, Municipal Buildings, Liverpool, 2.

THOMAS ALKER,
Town Clerk.

(J.6383) E5957

Indent NR 604 (1121)

THE GOVERNMENT OF NORTHERN NIGERIA

requires 3 EXECUTIVE ENGINEERS (Electrical) on favourable contract terms.

QUALIFICATIONS :

A University Degree or Diploma exempting from Parts I, II and III of the Institution of Electrical Engineers examination, OR to have passed Parts I, II and III of the Institution of Electrical Engineers examination or be otherwise experienced in all. In addition any of the following will be an advantage:-

i) Several years experience in the design, specification of contracts associated with the electrical installation in Public Buildings, and water pumping stations.

ii) Experience is one or more of the following:-

Medium voltage distribution
Street lighting
Airconditioning plant
Refrigeration
Diesel Engines
Automobile Electrical Equipment
Supervisor control of SRH.

DUTIES :

The preparation of design, specification and estimates, together with the supervision and maintenance of :-

a) Electrical installations in Public Buildings, S.R.H. Quarters, Hospitals, Schools, Water Pumping Stations, etc.
b) Diesel engine driven generating plant up to 500 KVA.
c) Medium voltage, overhead line and underground cable distribution.
d) The supervision and training of subordinate staff.

EMOLUMENTS :

1. **Salary.** According to qualifications and experience in the range of £1104 - £2202.
2. **Outfit allowance** of £45 and camp equipment allowance of £40 on first appointment.
3. **Resettlement Grant** of £37 . 10 . 10d. for each three months service inclusive of earned leave payable on satisfactory completion of contract.
4. **Children's allowance.** £120 for one child, £216 for two and £288 for three children eligible.
5. **First Class Passages** for officer and wife on appointment and on leave, and assistance towards cost of childrens' passages.

LEAVE :

Generous home leave on full pay.

Applicants should write to:— **The Recruitment Secretary (Overseas), Northern Region Recruiting Agency, Nigeria House, 9 Northumberland Avenue, LONDON, W.C.2.** or Telephone TRAfalgar 1244. Extension 145.

E5963

TENDERS

INDIA STORE DEPARTMENT

TENDERS

The Office of the Director General, India Store Department, Government Building, Bromyard Avenue, Acton, W.3, invites TENDERS for the following :

(a) HORIZONTAL TURRET LATHE, max. swing over bed 572mm., max. swing over cross slide 317mm., dia. of hole through spindle 108mm. ... ... 1 off
(b) HEAVY DUTY PLANO MILL with milling heads, one each on uprights and two on cross slide—Sliding table 365mm. by 1219mm. ... ... 1 off
(c) HIGH SPEED GUN BARREL BORING AND TREPANNING MACHINE for barrels 18in. o.d. and 30ft. long. Full details of boring operations available.
(d) SHELL LATHES for internal blending. Jobs 3in. to 4in. dia. and 18in. long. Drawings available.

Specifications, &c., can be obtained from the Co-ordination Branch, India Store Department, Government Building, Bromyard Avenue, Acton, W.3, at a cost of 10s. per Tender enquiry and is not refundable. Tenders are to be returned to the above address by Monday, the 24th October, 1960.

Specimen copy of the above enquiries can be seen at Engineering Branch, I.S.D., under the following references :

(a) 2001/60/SGH/ENG. 3.
(b) 2012/60/SGH/ENG. 3.
(c) 2017/60/SGH/ENG. 3.
(d) 2027/60/SGH/ENG. 3. E5920

FORTH ROAD BRIDGE

CONTRACT NO. 5 (ROAD WORKS NORTH OF FIRTH OF FORTH)

TENDERS are invited from experienced Contractors for the execution of work comprising :

(1) Approximately 3½ miles of Dual-Carriageway Approach Roads and 4 miles of Connecting Roads ;
(2) Ten Reinforced Concrete Bridges ;
(3) 600 foot long Reinforced Concrete Viaduct ; and
(4) 1000 foot long Twin Tunnels.

Copies of the Contract Documents and Drawings may be obtained from the Consulting Engineers, Messrs. Mott, Hay & Anderson, 14 Melville Street, Edinburgh, 3, on payment of a deposit of £30 by cheque made payable to the Forth Road Bridge Joint Board. The deposit will be repayable when a bona fide Tender has been received and all drawings returned.

Tenders must be sent in sealed plain cover marked "Tender for the Forth Road Bridge Contract," and addressed to The Clerk, Forth Road Bridge Joint Board," City Chambers, Edinburgh, 1, so as to be received there not later than 15th November, 1960.

The Joint Board do not bind themselves to accept the lowest or any Tender.

W. BORLAND,
Clerk to the Forth Road Bridge Joint Board.
E5913

MERSEY RIVER BOARD

BEDFORD-ATHERTON-PENLEACH DRAINAGE

CONSTRUCTION OF LOW CULVERTS UNDER HOLDEN ROAD, LEIGH

TENDERS are invited for the CONSTRUCTION of TWIN LOW LEVEL CULVERTS 9ft. by 6ft. by 110ft. in length, in Reinforced Concrete, under Holden Road, Leigh. The work to be carried out in heading.

Specifications, Bills of Quantities, Conditions of Contract and Form of Tender may be obtained from J. T. Firth, B.Eng., M.I.C.E., Engineer to the Mersey River Board, Liverpool Road, Great Sankey, Warrington, on payment of a deposit of £2 2s. to be refunded on receipt of a bona fide Tender and return of all documents.

Tenders in plain sealed envelopes, endorsed "Holden Road Contract" must be received not later than Monday, 24th October, 1960.

The Board do not bind themselves to accept the lowest or any other Tender.

R. E. WOODWARD,
Clerk of the Board.
Liverpool Road,
Great Sankey,
Warrington. E5922

INDIA STORE DEPARTMENT

20033/60/HSK/HAL.2 ⅞

The Director General of India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the supply of : 20033/60/HSK/HAL.2

AIR COMPRESSORS—vertical, two stage, double acting, 8in. stroke, 520 C.F.M.—2 Nos.

The Tender forms with schedules and specifications which are returnable on Thursday 27th October, 1960, may be obtained from the above office (C.D.N. Branch) on payment of a fee of ten shillings (not refundable) for each Tender.

The applications for Tenders should clearly state the above reference number. E5954

EDUCATIONAL

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page, prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 8

EDUCATIONAL

NATIONAL COLLEGE FOR HEATING, VENTILATING, REFRIGERATION AND FAN ENGINEERING

at

Borough Polytechnic, Borough Road, London, S.E.1.

A course of Eight Lectures

on

TUBULAR HEAT TRANSFER EQUIPMENT

Monday evenings, beginning 24th October, 1960

Other subject to be offered in 1961 include

(i) Drying and the theory of mass and heat transfer
(ii) Refrigeration heat and mass transfer
(iii) Experimental techniques.

Application forms and further information from : Fredk. J. Packer—Clerk to the Governors.

E5955 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AN INTERNATIONAL FOOTWEAR MANUFACTURER AND DISTRIBUTOR require the services of an INDUSTRIAL ENGINEER. Applicants should be capable of preparing drawing board layouts of new factories and extensions to existing factories based on latest methods of material handling and work flow. The successful applicant would be expected to have a basic knowledge of electric power, lighting distribution and installations ; a basic knowledge of methods study and have a plant engineering background. Some knowledge of the French language would be advantageous. Location will be in modern offices in Oxford Street, W.1, with the opportunity of occasional visits abroad as work requires. Good salary with life cover and pension scheme will be offered to the right man.—Write in first instance to the Personnel Manager, 151, Oxford Street, London, W.1. E5929 A

SITUATIONS VACANT

APPLICATIONS ARE INVITED FOR THE POST OF TECHNICAL OFFICER in the Production Tool Design Office of the Engineering Dept. at Ferodo Ltd., to be capable of undertaking the design and development of press tools, moulds, jigs and fixtures for metallic and non-metallic components. The applicant should not be less than 28 years of age, and should hold at least the Higher National Certificate in Mechanical Engineering.—Write, giving details of age, training, experience, and salary required, to the Personnel Manager, Ferodo Ltd., Chapel-en-le-Frith, Via Stockport. E5970 A

ARTHUR GUINNESS SON & CO. (PARK ROYAL) LTD., require an Engineering Designer Draughtsman on their permanent staff. Applicants should have at least a National Certificate in Mechanical Engineering with working and Drawing Office training. Experience preferably in Design and Detail Work in Chemical and Process plants, Services, Pipework Mechanical Handling and General Mechanical Engineering. Age 28-35. Commencing Salary £950 to £1050 with annual increments. Non-contributory Pension and excellent amenities.—Apply to the Personnel Manager, Park Royal Brewer, N.W.10. E5950 A

ASSISTANT TO CHIEF ENGINEER required by CHAMPION SPARKING PLUG CO. LTD., Feltham, Middlesex to maintain technical liaison with Engine Manufacturers in U.K. and Europe. The work is interesting and varied and will involve considerable travel on Continent. A good salary with all expenses and Company Car will be offered to suitable applicant, aged about 30, who must have Engineering Degree or equivalent, good French and German and preferably some Italian. Practical experience on Internal Combustion Engine development and use of associated test equipment is necessary. Written applications to the Chief Engineer will be treated in confidence and must give age, education, qualifications, experience, previous salaries and recent photograph. E3008 A

BRITISH WATERWAYS require an ENGINEERING ASSISTANT in their Divisional Engineering Department at Liverpool. Preference given to applicants with Corporate Membership of the Institution of Civil Engineers. Experience in administration associated with civil engineering work and the supervision of works being carried out by Contractors. Salary range £1095 to £1330 per annum ; contributory superannuation fund ; certain reduced travel facilities.—Applications, stating age, qualifications and experience to Divisional Manager, British Transport Waterways, Lime Street Chambers, Lime Street, Liverpool, 1. E5919 A

CONSULTING CIVIL ENGINEERS require capable assistants in their London Office for varied and interesting work in United Kingdom and Overseas. Five day week and luncheon vouchers.—Apply giving full particulars to Maurice Nachshen and Partners, 58, Victoria Street, London, S.W.1. E5956 A

SITUATIONS VACANT

CONSULTING ENGINEERS in Westminster require Engineer to take charge of site investigations and soil mechanics laboratory. The post offers excellent scope for a well qualified, energetic man.—Full details to BOX No. E5958, " The Engineer." A

DRAUGHTSMAN required for design of pressure vessels to A.O.T.C. requirements, also chimneys, flues and ductwork, &c., 5-day week, pension scheme. State experience, age and salary.—BOX No. E3010, " The Engineer." A

DRAUGHTSMAN required at L.C.C. Brixton School of Building, Ferndale Road, S.W.4., preferably with experience in structural engineering or architectural work. O.N.C. or similar qualification an advantage. Rate within scale 85s. 6d. by 12s. 6d. to 273s. according to age and experience. Form from Secretary. Please quote ref. (Estab. 7/E/2326/9). E5947 A

DRAUGHTSMAN required to work on valve design. Good working conditions, pension scheme, &c. All applications will be treated in confidence.—Apply in writing to Chief Engineer, a Alley & MacLellan Ltd., Bromyard Road, Worcester, quoting reference E.R. E5924 A

ENGINEER, 1st Class M.O.T., A.M.I.Mech.E. Preferably with Engineering Insurance experience as assistant to Chief Engineer of Engineering Insurance Association. Age about 35.—Particulars to ; Box ZO 246, Deacons Advertising, 36 Leadenhall Street, E.C.3. E5893 A

ENGINEERS, DRAUGHTSMEN, and all Technical staff, are invited to forward details of qualifications, etc., to Abbatt Technical Division, who will handle and negotiate on their behalf, without charge, any change of employment contemplated. Leading Organisations consult Abbatt, 25, Kensington High Street, W.8. WES. 0768-9. E2993 A

ENGINEER MECHANIC required for Industrial Design (Engineering) Dept., Central School of Arts and Crafts, Southampton Row, W.C.1. Skilled fitter and machinist for maintenance of machine tools and apparatus. O.N.C. in engineering or equivalent essential. £11 19s. 3d. for 44 hour week. Applications returnable to school not later than 1st October (Estab. 7/2325/E/9. E5949 A

ESTIMATOR. Minimum age 28. Higher National Certificate, engineering apprenticeship ; experience of conveying and screening preferred but not essential, excellent prospects. Five day week.—Apply in writing giving particulars of age, experience &c., Sales Director, Robert Cort & Son Ltd., READING. E5953 A

ESTIMATOR with experience of fabrication and all types of machining, also good general engineering background. Age 35-50. The vacancy is with Lansing Bagnall, Britains leading Mechanical Handling specialists, whose factory is on the outskirts of a pleasant Country-Town in the South of England one hour west of London.—Apply in first instance with full particulars to J. Dewar, Personnel Manager, Lansing Bagnall Ltd., Kingsclere Road, Basingstoke. E5935 A

ESTIMATING AND PLANNING ENGINEER experience of fabricated and machined structures and vessels essential.—Applications in writing to BOX No. E3002, " The Engineer." A

JOHNSON, MATTHEY & CO., LIMITED have a few vacancies for young men in their engineering factories near London, who wish to make a career in Production Management.

Candidates, who should be between 25 and 30, should preferably have had a recognised engineering apprenticeship and an H.N.C. in Production Engineering. Preference will be given to candidates with some experience of production control in light engineering.

Write, giving full details of qualifications, experience, age, &c., to the Secretary of the Company, 78 Hatton Garden, London, E.C.1.

E5951 A

LADY TRACER required in Westminster area—Consultant's office. Previous experience of civil engineering work helpful. The work is varied and interesting. A good standard of lettering is essential. Salary will be considered in relation to experience and ability. Age range preferred is 25 to 40 years.—Please submit details experience etc. to BOX No. E5932, " The Engineer." A

MUNICIPAL MUTUAL INSURANCE LIMITED has vacancies for Mechanical engineer surveyors in Birmingham, Cardiff and London. Posts are pensionable and permanent to satisfactory candidates who should have served an apprenticeship and have sound practical and theoretical knowledge. Technical qualifications : First Class Ministry of Transport certificate. Salary : £800 rising to £1100 per annum.—Apply in own handwriting marking the envelope " Application Engineer Surveyor " and " Private and Confidential " to the Chief Engineer, 22, Old Queen Street, London, S.W.1. E5969 A

NIGERIAN ALLUVIAL TIN MINING

Established Company in the Plateau Province requires immediately an experienced practical ENGINEER/MECHANIC with good knowledge of pumping equipment. Single man between the ages 25-30 preferred. Three months paid leave after every eighteen months tour with passages paid U.K., housing provided. Salary £85 per month, Pension Scheme.—Write full particulars BOX No. E3007, " The Engineer." A

PROJECT ENGINEER

A vacancy exists for an Engineer to join a small team engaged on project work in connection with improvements and new processes in the seamless steel tube industry.

The work is interesting and varied and may cover all aspects of a project from initial feasibility trials to the design, installation and commissioning of the final production unit.

The nature of the work is such that absolutely similar experience cannot be expected from candidates, and preference will therefore be given to a man who can demonstrate the qualities of versatility and energy, as well as qualifications up to degree standard in mechanical or electrical engineering.

Applications, from men in the age group 28-32, should be addressed to the Works Director, Tubes Limited, Kirby Muxloe, Nr. Leicester, giving brief personal history to date and salary expected. E5887 A

SITUATIONS VACANT

SENIOR ENGINEER

Wanted by Paper Mill new Dublin, Senior Engineer, with at least twenty years' experience of maintenance of heavy plant and installation of new plant on an extensive scale. University Graduate or Member of Institution of Mechanical Engineering preferred. Good salary offered to proved competent hard worker.—Apply to BOX No. E3004, " The Engineer." A

SENIOR MECHANICAL DESIGNER DRAUGHTSMEN

Bell Punch Company Ltd., Uxbridge, Middlesex have vacancies for senior draughtsmen accustomed to the preparation of production drawings from prototype design. Education to H.N.C. or O.N.C. standard and experience in light engineering industry desirable.

Salary by arrangement. Apply in writing giving fullest details of experience and qualifications to Personnel Department. E5964 A

SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN required for interesting work on large chemical plant installations. Experience in this type of work is desirable but not essential and applicants with general mechanical engineering experience will be favourably considered. The posts offer opportunities and salaries consistent with experience and ability. Modern offices situated in the London, E.C.4 area. Five-day week and superannuation scheme.—Applications, which will be treated in the strictest confidence, giving details of age, qualifications and experience and quoting ref. LCL/TE2/67, should be addressed to The Group Personnel Manager, LAPORTE INDUSTRIES LIMITED, Hanover House, 14 Hanover Square, London, W.1. E5967 A

TECHNICAL AUTHOR required, not over 50, to assume responsibility for the compilation of operating and maintenance instruction manuals dealing with the Company's machinery. This interesting and progressive pensionable staff position would appeal to a suitably qualified Mechanical Engineer with a bias towards technical writing.—Applications should be addressed to the Personnel Manager, Molins Machine Co. Ltd., Evelyn Street, London, S.E.8. E5962 A

TECHNICAL REPRESENTATIVE wanted for Sheet Metal machines and Machine Tools. N.W. London and Home Counties area. Non-contributory Pension and Assurance scheme.—Details of experience and salary required to Managing Director, F. J. Edwards Ltd., 359, Euston Road, London, N.W.1. E5972 A

TECHNICAL SALES REPRESENTATIVE required for sale of high and low pressure pipework and steel fabrications up to 70 tons, to cover the counties of Northumberland, Durham and Yorkshire. Must have sound engineering background, and be capable of negotiating business at all levels. Only men of highest integrity and those able to work on own initiative will be considered. The position offers great scope to the right man. Car provided ; Staff Pension Scheme.—Send full details of age, past experience, qualifications and salary required, in own handwriting to BOX No. E3003, " The Engineer." A

THE DISTILLERS COMPANY LIMITED

DESIGNER DRAUGHTSMEN

The Company has two vacancies in its Engineering Division in London, W.1, for Designer Draughtsmen. Candidates, in the age range 25-40, should have had experience in industrial and chemical plant lay-out, piping schemes, and pressure vessels. They should have obtained at least the Higher National Certificate (Mechanical). The Company has a non-contributory pension scheme, and other fringe benefits are available.

Write : Staff Manager
THE DISTILLERS COMPANY LIMITED
21-22 BOLTON STREET
LONDON, W.1.

Quote Ref.: 102/60 T.E.

E5926 A

THREE DETAIL DRAUGHTSMEN required in Consulting Engineers office for reinforced concrete work and structural work in the Birmingham area. Top grade salaries will be paid to the appointed men. Five-day week. Pension Scheme.—Apply in the first instance by letter, stating age, qualifications and salary required.—BOX No. E5867, " The Engineer." A

TECHNICAL ASSISTANT REQUIRED by established Rotary Compressor Manufacturers. D.O. experience essential. Good salary to engineer with right technical background.—Apply Tech. Manager, the B.A. Holland Engineering Co. Ltd., Lindo Lodge, Chesham, Bucks. E2990 A

WORKS MANAGER to take charge of medium-sized specialist fabrication works. Experience in specialised construction of medium and heavy fabrications essential. —Applications in writing, stating qualifications and experience, to BOX No. E3005, " The Engineer." A

Classified Advts. continued on page 126

BOOKS and PUBLICATIONS

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This book is designed primarily for those already engaged in the sphere of personnel management and industrial relations but readers with little or no experience will find it a help towards understanding the problems, opportunities and challenges in this expanding field. Price 60s. net.

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HOUSING ASSISTANCE MAY BE POSSIBLE

Applications to be sent to:— Technical Personnel Officer, c/o Dept. G.P.S. English Electric House, Strand, London, W.C.2. quoting reference E1399U.

ENGLISH ELECTRIC AVIATION LTD
Guided Weapons Division
London — Luton — Stevenage

E5914 A

SITUATIONS VACANT

APPLEBY-FRODINGHAM STEEL COMPANY, SCUNTHORPE, LINCOLNSHIRE,

invite applications for a

SENIOR DESIGNER

with experience of heavy PLATE AND SECTION ROLLING MILLS PLANT.

Permanent situation with interesting and varied work.

Apply, giving age, full particulars of experience, &c., to The Chief Engineer.

E5804 A

SITUATIONS VACANT

ASSISTANT FACTORY MANAGER
(Engineering)

for the Manchester factory of a major Group and employing approximately 100 people. Starting salary £1200 p.a. plus pension scheme and annual bonus based on profits.

The Unit consists of press and fabrication shops, tool room, maintenance and transport departments etc. and comes under the Director and Factory Manager in charge of some of the Group's Subsidiary Engineering Factories. The Assistant Factory Manager will be responsible to this Director for the effective control of all departments of the Manchester Factory. This will involve obtaining maximum utilization of equipment and ensuring the provision of suitable tools in order to meet production programmes.

Desired qualifications include several years engineering experience including press and fabrication work, some of this should have been in a supervisory capacity. Other requirements are an interest in tool design, and the ability to interpret drawings. A qualification in mechanical or production engineering will be of advantage but practical experience is the primary need. Preferred age 30-40.

Please write briefly in first instance: quoting Reference No. 826 to :

AA LTD

ASHLEY ASSOCIATES LTD.
PETER HOUSE, MANCHESTER 1.
RETAINED TO ADVISE ON THIS APPOINTMENT
The strictest confidence will be observed and no details of candidates will be passed to clients without candidates' permission.

E5952 A

THE GENERAL ELECTRIC COMPANY LIMITED
ATOMIC ENERGY DIVISION

PRESSURE VESSEL ENGINEERS
Erith and Tokyo

Vacancies exist in the Contracts Department at Erith for Pressure Vessel Engineers for Nuclear Power Station contracts.

Applicants should hold H.N.C. as minimum qualification and should have experience of the design of pressure vessels to the requirements of Lloyds Register of Shipping and the various codes. Some commercial experience would be an advantage.

The positions are permanent and pensionable.

After a period of service at Erith, Engineers would be considered for vacancies in the Tokyo Office of The British General Electric Company of Japan.

Write for application form in the first instance to the Personnel Manager (A.H.H.D.), The General Electric Company Limited, Erith, Kent.

E5945 A

BABCOCK & WILCOX LIMITED
ATOMIC ENERGY DEPARTMENT

Vacancies exist for **DESIGN ENGINEERS** preferably possessing an engineering degree or equivalent in the Company's Head Office in London.

(1) **PROJECT DESIGN.** Applicants should be capable of original design in the field of mechanical and thermal engineering and should be able to carry out work in the first place on components and later the whole of nuclear steam generating plant.

(2) **HEAT EXCHANGER DESIGN.** Applicants with similar capabilities will work on advanced heat exchangers for gas and water cooled reactors.

(3) **PRESSURE VESSEL DESIGN.** Applicants should be capable of undertaking the design and stress analysis of special pressure vessels of the type used in nuclear power plant.

Write giving details of qualifications and experience to :

The Assistant Secretary,
Babcock & Wilcox, Ltd.,
209, Euston Road,
London, N.W.1.

E5930 A

TAYLOR WOODROW CONSTRUCTION LIMITED

due to the development of the

MECHANICAL INSTALLATION DEPARTMENT

require

ENGINEERS

for the design of mechanical services.

PIPING DRAUGHTSMEN
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with experience of the design of instrumentation systems and of site installation and calibration.

CHEMICAL ENGINEERS

with experience of the design and construction of chemical plant.

and

SITE AGENTS

with experience of chemical, refinery and heavy industrial installations.

These are excellent opportunities to join a rapidly expanding department and offer scope for responsibility and advancement to men of ability.

Write to :

Personnel Manager,
345, Ruislip Road,
Southall, Middlesex.

E5974 A

SUPER OIL SEALS & GASKETS LTD.

WORKS MANAGER

A Works Manager is required to take charge of the Company's light engineering division in Birmingham which employs 800 and is still growing. The Company's total staff numbers about 2,000.

Works Managers who have had the experience of planning and organising production for a plant of similar or larger size are invited to apply for this appointment. Applicants must have had practical machine shop and press shop experience.

Salary for this important position will be commensurate with qualifications and experience. The Company has a generous superannuation and life assurance scheme.

Write, stating age, qualifications and experience to :

The Director & Secretary, Super Oil Seals & Gaskets Ltd., King's Norton, Birmingham, 30.

E5961 A

SITUATIONS VACANT

MSL *have been retained to advise on the appointment of*

DIVISIONAL MANAGERS

for a precision machine tool company in Buckinghamshire who wishes to recruit Divisional Managers to take respective charge of its two main activities. The company is a member of a large engineering group, and, in addition to developing and expanding its traditional business in the open market, is engaged in building up its special role as designers and manufacturers of plant and equipment for the other group companies. The new Managers will be responsible to the Managing Director for the conduct of these separate sides of the business and should be of a calibre to suit them for appointment to the Board at an early stage.

The candidates should have appropriate qualifications in mechanical engineering. They should have knowledge of modern machine tools, preferably on the design and manufacture side, or, alternatively, in their application for quantity production in medium and light engineering. Experience of special purpose machine tools and linkage methods would be a strong recommendation. In addition, they must be able to show evidence of aptitude for overall management and have the personal qualities to suit them for the further promotion.

Depending on previous experience, ages up to 45 will be considered but the preferred age would be about 35. The starting salary will be based on ability and experience and will be by negotiation and should be in the region of £2,500 per annum, or higher than this in exceptional cases. The positions will carry a motor car and non-contributory pension scheme. Please send brief details in confidence quoting reference G.2317 to M. B. Berks.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

E5916 A

SITUATIONS VACANT

FIBREGLASS

RESEARCH AND DEVELOPMENT MECHANICAL ENGINEERS

If you have a good honours degree in Mechanical Engineering and would like to hold a responsible job in an expanding industry, you are invited to write about yourself to **Mr. A. de Dani, Manager, Research and Development, Fibreglass Ltd., St. Helens, Lancashire.**

You would be given varied and interesting work on all process and product development on existing plant and design and operation of new plant and processes. Based on St. Helens, you would have occasion to visit works in Glasgow and Birkenhead.

E5917 A

PILKINGTONS

MECHANICAL ENGINEER

If you have a good honours degree in Mechanical Engineering plus Graduate or Associate Membership of the Institution of Mechanical Engineers and would like to join the Commonwealth's largest glass manufacturing organisation, you are invited to write about yourself to the Personnel Officer (Graduate Recruitment), Pilkington Brothers Limited, St. Helens, Lancashire.

You would be responsible direct to the Works Mechanical Engineer for the installation of new plant and improvement and maintenance of existing plant, including the Pilkington invented "Twin Grinder" licensed to flat glass manufacturers throughout the world. You would find ample scope for initiative and responsibility and there would be opportunity for early promotion within the Group.

The greatest name in the world of GLASS

E5915 A

NUCLEAR POWER STATIONS COMMISSIONING ENGINEERS

A Company engaged in the design, construction and commissioning of nuclear power stations has vacancies for Commissioning Engineers in its Commissioning Department. Successful candidates will be trained in the operation of nuclear power stations and should have experience in the operation of conventional plant. They should be either associate members of a major professional institution or hold qualifications leading to associate membership.

Applications should be addressed to Box E 1042 LPE Romano House, 399/401 Strand, London W.C.2., and give details of age qualifications, experience and current salary.

E5966 A

An Internationally-known Swedish manufacturer of ventilating and air-conditioning equipment seeks

A BRITISH SALES ENGINEER

to organise and develop sales of the Company's products in the United Kingdom.

Qualifications : B.Sc. Eng., or equivalent and Associate Membership of the Institute of Heating and Ventilating Engineers. Ability to conduct business at all levels essential. Experience in selling ventilating and air-conditioning equipment desirable. Preferable age : 30 to 35.

The successful applicant will be given a minimum of one year's training at the Company's plant in Sweden.

Applications concerning this appointment should be addressed to Bahco-Condrup Ltd., 67-73, Worship Street, London, E.C.2, giving fullest details of education, qualifications, present position and salary and should include two recently taken photographs of the applicant. Envelopes should be marked "British Sales Engineer."

E5969 A

Machine Tool Industry Research Association

Negotiations are now well advanced for the formation of a D.S.I.R. grant aided Research Association for the Machine Tool Industry and applications are accordingly invited for the post of **Director of Research.**

In the initial period, work on research projects would be placed out under contract with existing Research Centres under the supervision of the Director to be appointed.

The post demands the highest administrative and negotiating ability, academic qualifications and technical experience. It will carry a salary commensurate with these requirements. The post will be pensionable.

Written application, which will be treated in the strictest confidence, should be submitted within one month from the date of this advertisement to :—

The Chairman of Council,
Machine Tool Industry Research Association,
Brettenham House, Lancaster Place, London, W.C.2.

Envelopes should be clearly marked "R.A. Application."

E5918 A

Classified Advts. continued on page 128

SITUATIONS VACANT

A MECHANICAL ENGINEER

is required by the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY AT WINDSCALE AND CALDER WORKS CUMBERLAND

to work in the Engineering Section of the Technical Branch which is studying engineering aspects of reactors, irradiated fuel handling facilities and chemical plants processing irradiated fuel elements. The work requires a practical outlook as it is directly concerned with operating plant, and also a sound theoretical knowledge as radiation problems frequently preclude the use of standard materials of construction and normal testing methods.

Applicants must have served a recognised engineering apprenticeship and be corporate members of the Institution of Mechanical Engineers, or equivalent. A good Honours Degree in Mechanical Engineering may be an advantage and several years' experience on Technical work involving heat transfer and/or stress analysis is highly desirable.

Salary within the scale £1370—£1825 p.a. according to qualifications and experience. Contributory Superannuation. Staff Housing Scheme.

Send postcard for application form quoting reference P/W.52/J1 to Recruitment Officer, Production Group, U.K.A.E.A., Windscale Works, Sellafield, Seascale, Cumberland.

Closing Date: 10th October, 1960. E5944 A

DRAUGHTSMEN

Draughtsmen are required at the Midlands Research Station, Solihull.

The duties are interesting and will include work on the design of pilot and prototype plant associated with the development of new high-pressure processes for the production of town gas.

Candidates should possess at least an O.N.C. certificate in Mechanical Engineering.

The salary for the appointments, which are pensionable and subject to medical examination will be within the range of £770-£1015 per annum.

Applications, stating age, education and experience, should be addressed to the Industrial Relations Officer,

WEST MIDLANDS GAS BOARD,

6, Augustus Road, Edgbaston, Birmingham, 15

E190 A

CENTRAL ELECTRICITY GENERATING BOARD

ASSISTANT ENGINEERS

Applications are invited for two appointments as ASSISTANT ENGINEERS in the Planning Department at Headquarters, London, S.E.1. Both will be in the Development Section (Policy) as members of a group dealing with the energy resources available for electricity generation and their economic utilisation in the long term. An essential in each case is a capacity for forward thinking.

Second Assistant Engineer

This appointment will have special reference to the coal industry and to coal transport. Experience in, or association with, the coal or transport industries of this country will be an advantage. The applicant should hold a university degree or similar qualification.

Salary on a scale within the range £1,385—£2,010 p.a., according to duties and responsibilities.

Fourth Assistant Engineer

The appointment will be concerned with fuels generally and with the pattern of energy use in the national economy. Experience in the electricity supply industry or in another fuel industry will be an advantage.

Salary on a scale within the range £930—£1,375 p.a., according to duties and responsibilities.

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24/30, Holborn, London, E.C.1., by 3rd October. Envelopes should be marked "Confidential Ref. ENR/326."

E5912A

SITUATIONS WANTED

MACHINE TOOL ENGINEER

Swiss Machine Tool Engineer seeks position in British works. Available 1961.—J. Birrer, Kasimir-Pfyfferstrasse 14 Luzern, Switzerland. E2975 B

SUB-CONTRACTING

KELLERING AND CAM PROFILING capacity up to 8ft by 6ft or 6ft diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone: Knottingley 2743/4) E116 MW

PATENTS

THE PROPRIETOR of British Patent No. 775336, entitled "METHOD AND APPARATUS FOR FORMING CONCRETE PIPE IN SITU," offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern & Carlberg, 140 South Dearborn Street, Chicago 3, Illinois, U.S.A. E5902 H

THE PROPRIETOR of British Patent No. 780117, entitled "DEVICE FOR SEALING FLUID LUBRICANT IN THE HUB OF A ROTATING WHEEL," offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern & Carlberg, 140 S. Dearborn St., Chicago 3, Illinois, U.S.A. E5942 H

MISCELLANEOUS

STAINLESS STEEL SPLIT PINS 2½in. by ¼in. £7 per 1000. 10 per cent. Reduction for 5000 or more. Ransome & Marles and other bearings about half-price, send requirements.—L. BROOKS & CO., 48, Church Road, St. Annes-on-Sea. E3006 I

MOBILE LIFTING SERVICE. Lump Sum or Hire Rate quoted for any lifting work by Lorry-Mounted or Crawler Cranes, any size, any area.—MOBILE LIFTING SERVICES LTD., A member of the TARMAC Group, Rotherham 78481. E186 I

BUSINESSES and PREMISES

GATESHEAD MODERN prestige river side factory 28,000ft. Freehold for sale.—Details: Knight, Frank & Rutley, 20 Hanover Square, London, W.1. E5960 L

BUSINESS OPPORTUNITIES

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Send for details which show an attractive proposition to manufacturers.

Write to the
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REMPLOY LTD.,
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or telephone VICtoria 6621 (12 lines)

E5847 O

Measuring and Precision Engineering Machinery

A Belgian company situated in an important industrial centre, possessing highly qualified staff, with buildings and land occupying approximately 5 acres seeks

Manufacturing Rights
(under License)
for the
Common Market Area

Bank and other first class references available. BOX No. E3011, "The Engineer."

E3011 O

MACHINERY Etc. WANTED

WANTED FOR CASH all types of Electrical, Plant, A.C. & D.C. Motors, Diesel Generating Sets, Transformers, Turbo-Alternators, Cables Dismantling Staff Available.—ELECTRICAL PLANT & MACHINERY Co., 12 Hilton St., E.1. E5895 F

WANTED TWO 5 TON OVERHEAD TRAVELLING CRANES

50ft. span, standard A.C. electrics, cab control, headroom 6ft. 2in.

REED BROTHERS (ENGINEERING) LTD.
Replant Works,
Woolwich Industrial Estate,
London, S.E.18.
Tel.: Woolwich 7611/6. E5933 F

MACHINERY Etc. WANTED

MULTI-DRILL CORONA 16MX or 20MX or similar with adjustable head minimum ten spindles wanted urgently. New or good used machine preferred.—Write or phone: The Armfield Hydraulic Engineering Co. Ltd., Ringwood, Hants. Tel.: Ringwood 760. E3009 F

FOR SALE

FRED WATKINS (ENGINEERING) LTD.

STEAM BOILERS.—Cochran Vertical (New) 7ft. and 6ft. 6in. dia., 150 lb. w.p.; reconditioned 9ft. down to 3ft. dia.; Economic 4ft. to 11ft. 6in. dia., including new 8ft. dia., 150, 180 and 200 lb. w.p.; 300 reconditioned Vertical Crosstubes, all sizes.

AIR COMPRESSORS.—Two Belliss & Morcom 2500 c.f.m., 100 p.s.i., 550 h.p. motors; also Broomwade 500,400,300,200 and 130 c.f.m., all motorised; and several others of various makes and capacities.

200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 200 h.p.

MOBILE ROAD CRANES.—10-ton Lorain lorry-mounted 30ft.-70ft. extendible jib; 8¼-ton Ransome Diesel/Electric 21ft. jib; 6-ton Coles Diesel/Electric, solids; 4-ton Coles Diesel/Electric, solids, 1945; 3-ton Jones "Super 40" diesel, pneumatics (3).

OVERHEAD CRANES.—25-ton Girders and end carriages, with 60 h.p. motors, 95ft. 10in span; 30-ton Vaughan, 42ft. 3in. span; 25-ton Clyde, 21ft. 9in. span, new 1954; 20-ton Vaughan, 42ft. 3in. span, 6-ton auxilliary, cab control (5); 20-ton King, 42ft. 3in. span, 400/3/50; Wharton, 7½-ton, 25ft. span, 400/3/50; 5-ton Henderson, 24ft. 7in. span, 1946; 5-ton Morris, 58ft. span, hand-operated; 5-ton King, 29ft. 3in. span, power hoist, hand travel; 5-ton Morris, 28ft. 6in. span, power hoist, hand travel; 4-ton Morris, 19ft. span, 220V. d.c. (3); majority of the above are unused.

DERRICK CRANES.—7-ton Anderson Grice, 100ft. jib, electric; 1½-ton Anderson Grice, hand, 40ft. jib; 5-ton Butters Grabbing, 80ft. jib, electric.

RAIL CRANES.—18-ton Brownhoist, steam, 50ft. jib; 10-ton Grafton, 34ft. jib, diesel conversion; 8-ton Wilson, steam, 35ft. jib; 5-ton Smith, 50ft. jib (2).

LOCOS.—Fowler diesel, 150 h.p. (2); Barclay & Ruston, 80/88 h.p., diesel; Bagnall 14in. by 22in. (two oil-fired, one coal), Peckett, steam, 7in. by 12in., 1941; 4 Logan Battery-operated, 24in. gauge, 3-4-ton cap.; 3 Ruston diesel 16/20 h.p., 24in. gauge; also 2 miles 20 lb. and 1200 yds. of 25 lb. x 24in. gauge track, Bogies, Wagons, &c.

STEELPIPING.—Large stocks including following: 20,000ft. 1¼in. galvanised "A"; 20,000ft. scaffolding; 30,000ft. 3in. black; 15,000ft., each 6in., 3/16in., ¼in., 5/16in., unused; 5000ft., 8in. unused; 2000ft., 10in., 12in., 16in., seamless; 200ft., 24in. by ¼in. welded, unused; 1000ft., 30in. by ¼in. welded, unused; 2500ft., 27in. welded flanged; 500ft., 36in., unused; 500ft., 42in. by ¼in. riveted; 100ft., 48in. by ¼in. welded unused; 150ft., 60in. welded; 20in., 24in., 26in., 27in., 28in., bitumen lined, unused. Full list on request.

CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s., including 150 by 18ft. lengths, 6in. Stanton class "B" Spigot and Socket, unused. Immediate delivery.

VALVES.—Exceptional Surplus Ministry Lot. New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock all sizes, Parallel Slide Sluices, Gunmetal, Reducing and Check Valves. List on request.

STORAGE TANKS.—300 cylindrical and rectangular, up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.

MACHINE TOOLS.—Heenan & Froude Dynamometers, 1500 h.p. maximum, 18in. Dial Indicator (three) & Scriven Plate Bending Rolls, 14ft. by ¼in.; Berry Bending Rolls, 7ft. by ¼in.; Tangye 200-ton Hydraulic Vertical Straightening Press, 15ft. by 3ft. table; Herbert Miller, 61in. by 15in. table; Pels Punch and Shears, ¾in. capacity; nine new 2 cwt. and 1 cwt. Pneumatic Hammers; Bonn Hydraulic Tube Bender up to 20ft. by 4in. bore; Berry Guillotine capacity 4ft. by 1in.; Fielding Hydraulic Tube Bending Machine, 24in. stroke up to 8in. capacity; Sedgwick 6ft. by ¼in. Folding Machine; Rushworth Guillotines, 6ft. by ¼in., Bliss 70-ton power press.

SLING ENGINEERING WORKS
Phone: Colsford 2271/2. E106 G

11-ton Aveling-Barford diesel Road Roller, engine just overhauled.
110 c.f.m. BroomWade Portable Compressor, Lister diesel engine, on pneumatics, nice condition.
300/400 amp. Murex diesel-driven Portable Welding Set, sound order.
4½ cu. yd. Aveling-Barford diesel-driven Dumper, engine, skip and tyres good.

WILLIAM G. SEARCH LTD.
WHITEHALL ROAD, LEEDS, 12.
Tel.: 639081 (10 lines)
SEARCH (LIVERPOOL) LTD.,
HAMMOND ROAD,
KIRKBY TRADING ESTATE,
LIVERPOOL.
Tel.: Simonswood 3361 (5 lines).

E5925 G

HYDRAULIC PRESSES OF ALL TYPES

This week's selection:
3300-ton Twenty Daylight Sheet of Board Press, platens 12ft 6in. by 4ft. 6in. with self-contained Pumping Unit.
2000-ton Free Forging Press, bed 8ft. by 8ft. 6in.
1000-ton Vertical Extrusion Press with self-contained Pumping Unit.

REED BROTHERS (ENGINEERING) LTD.
Replant Works,
Woolwich Industrial Estate,
London, S.E.18.
Tel.: Woolwich 7611 (6 lines).

E5937 G

FOR SALE

Edwards

Double Sided Friction Screw Press, motorised for 400/440/3/50 supply, pressure exerted 50 tons, stroke 9in., between uprights 15½in., bed 15½in. by 20in., hole in bed 4½in. diameter, weight approx. 71 cwt.

TAYLOR & CHALLEN Double Sided Double Action Cam Action Drawing Press, can be supplied motorised for 400/440/3/50 supply, punch stroke 8in., blankholder stroke 4in., between uprights 20in., bed 18in. by 15½in., hole in bed 8in. diameter, weight approx. 45 cwt.

RHODES Motorised Double Geared Press Brake, motorised for 400/3/50 supply, pressure exerted 150 tons, forming capacity 10ft. by 3/16in. or 18ft. by approx. ¼in., length of stroke 5in., weight approx. 20 ton.

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45 boring and surfacing, centre, turret and precision lathes 4in to 14in centres ; 10 millers ; 6 K & W and other radial drills ; pneumatic hammers ; punching and shearing machine ; slotting machines ; universal precision grinders ; shapers ; hacksaws ; pillar and bench drills ; tool grinders ; wet grinders ; engraving machines ; B.O.C. pantograph profiling cutting machine ; arc welders and controllers ; spot welders ; welding kits ; case nailing and cleating machines ; woodworking machinery including : universal woodworker ; chain and chisel mortisers ; planers and thicknessers ; bandsaws ; plane and moulding iron grinders ; sharpening and gulleting machines ; woodturning lathes ; crosscutting and trenching machines ; cir. saw benches ; Weaver steam cleaners ; washing pumps ; electrical test benches ; core ovens ; heat treatment furnaces ; gen. sets ; dehumidifying and temperature refrigeration equipment with air compressors ; 30 trailer vans and trucks ; photographic equipment ; lenses ; projectors ; cameras ; blanketing ; electrical test instruments ; miscellaneous stores.

September 27-30	**Vehicles, motor cycles, earth moving and lifting equipment.**	W.D. Storage Depot, **Ruddington, Notts.**	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)

Approximately 2,000 motor vehicles ; earth moving plant ; mobile cranes ; trailers ; motor cycles etc. including : 29 excavators by Priestman ("Wolf") ; Ruston Bucyrus (" 10 " and " 19 RB ") ; Wayne (model " 40 ") ; 27 tractors, angledozers and bulldozers by Caterpillar (D6, D7 and D8) ; mobile cranes by Coles, Hyster, Lorain, Morris and Wayne (some diesel and/or lorry mounted) ; dumpers ; ditchers by Barber Greene ; 21 road rollers (2½-6½ tons) by Aveling Barford, Greens and Wallis Stoevens ; forklift trucks by Conveyancer and Coventry Climax (diesel) ; concrete mixers (diesel) by Stothert and Pitt ; trailer mounted fire pumps ; snow ploughs ; lorry mounted diesel generators 5·6-50 K.V.A. (some 230 volts) ; tractors (some with low-loading plant trailers) by A.E.C. ; Bedford, Diamond " T " and E.R.F. mobile tankers (self propelled and trailer mounted) 100-2500 galls ; 312 saloons, limousines and estate cars (including 120 Ford " Anglias," " Populars," " Prefects " and Morris " Minors ") ; 55 Land Rovers ; utilities ; tippers ; coaches ; and many other types of load carriers and dual purpose vehicles (some fitted with diesel engines) and 510 solo and combination motor cycles by Ariel, B.S.A., James, Matchless, Norton, Triumph, etc.

October 19	**Miscellaneous stores.**	Northern Command Ordnance Sub-Depot, **Barlow, Nr. Selby, Yorks.**	BARTLE & SON (Dept. L), 50-52 Merrion Street, Leeds, 2. (Tel.: 20898.)
October 25	**Machine tools and miscellaneous stores.**	W.D. Storage Depot, **Byley, Nr. Middlewich, Cheshire.** (Sale at Cheetham Town Hall, Manchester 8).	J. H. NORRIS & SON, (Dept. L), 9, Albert Square, Manchester 2. (Tel.: Blackfriars 8373.)
October 28	**Miscellaneous stores.**	Returned Stores Group, **Reed Hall, Colchester, Essex.**	FENN WRIGHT & CO., (Dept. L), 146 High Street, Colchester, Essex. (Tel.: 73171.)

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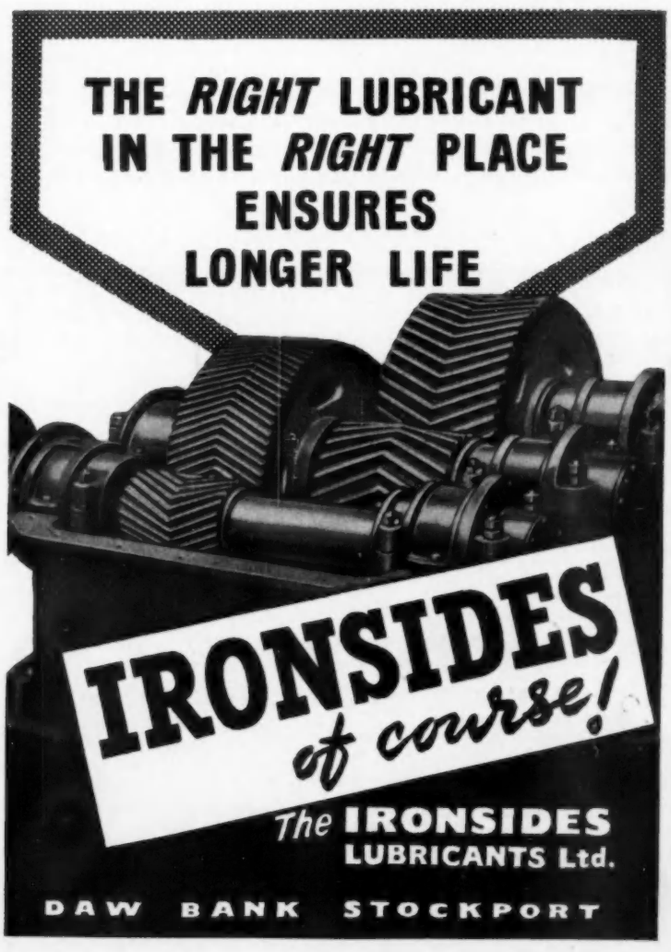

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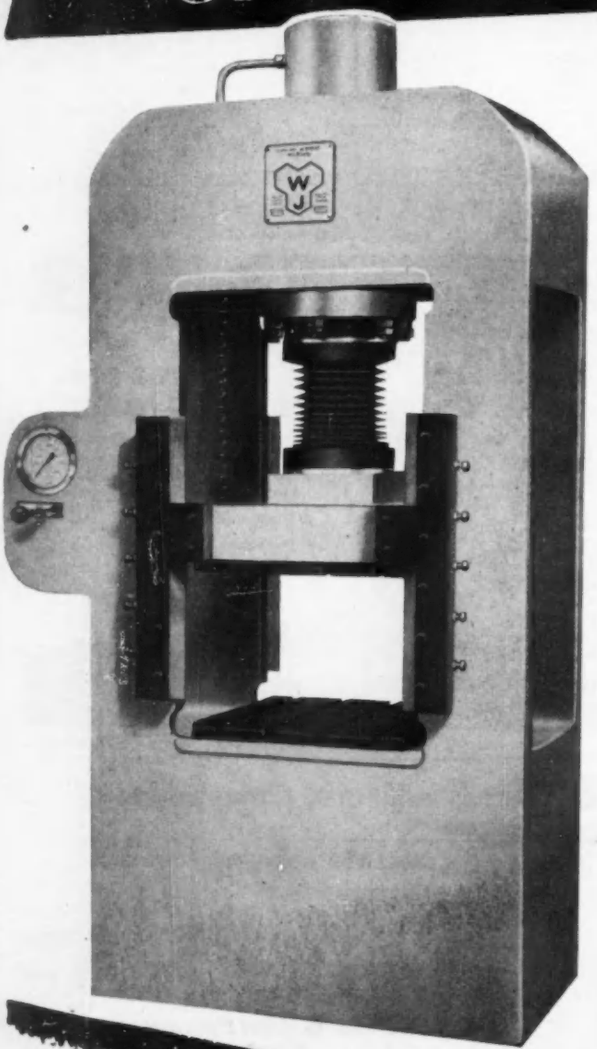
AND NOW...

PRESTIGE

FRAME PRESSES

TO SET A NEW HIGH STANDARD OF OVERALL EFFICIENCY



FAST-VERSATILE-ROBUST-COMPACT

The Prestige Range of Frame Presses has been designed for hard-working versatility: for bushing, bending, straightening, hot and cold forming of sheet and plate and for cold flow forging.

A variable calibrated pressure control valve enables accurate pressures to be pre-set. Cycle times are reduced by a 3 - position control lever, the neutral position holding the ram where required. All rams have power return, the oil systems being arranged for high approach and return speeds. The frames of Prestige presses are fabricated from heavy steel plate.

The Range of PRESTIGE Frame Presses			
CAPACITY	DAYLIGHT	STROKE	TABLE SIZE
50	24"	15"	24" x 24"
100	24"	15"	24" x 24"
150	24"	15"	24" x 24"
200	24"	15"	36" x 36"
250	24"	15"	36" x 36"

MANUFACTURED BY

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SEND FOR LEAFLET PF1 FOR FULL SPECIFICATIONS.

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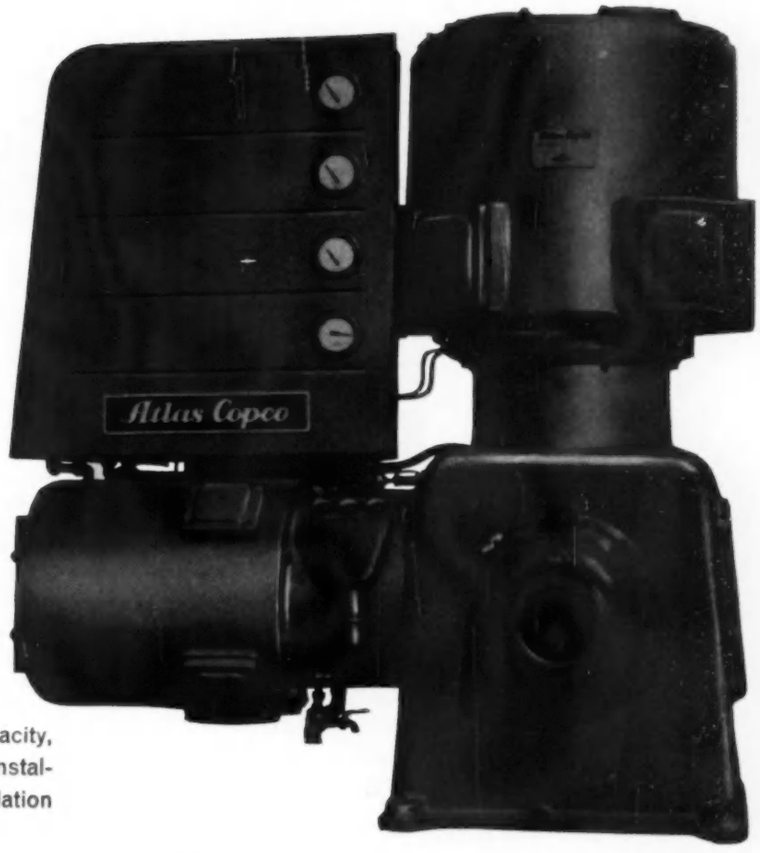
Here's Air Power at **ROCK BOTTOM** cost



ER6
HEAVY-DUTY Compressor for reliable 3-shift operation

Atlas Copco's ER6 compressor delivers air at the lowest possible cost. Designed to incorporate *every* economy factor, it combines the lowest possible running costs with low installation costs and a space saving design.

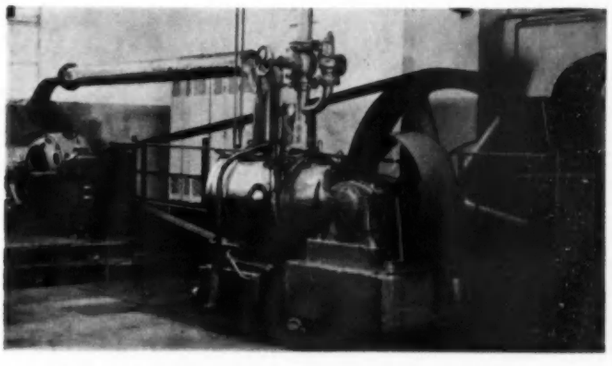
The ER6 delivers 1,075 cfm at 100 psi (30.4 m^3/min at 7 kg/cm^2) for a power consumption that is absolutely rock bottom. Thanks to a new type of intercooler, water consumption is only 440 imperial gallons (2,000 litres) per hour—a *quarter* the consumption of most similar machines. The ER6 is compact. Occupying only half the space usually required for machines of its capacity, it saves expensive factory space. In addition, installation costs are lower as new, cheaper installation methods are employed.

RANGE OF STATIONARIES

From 2.5 to 20,000 cfm, there is an Atlas Copco stationary compressor to suit every requirement. Whatever the design factor—compactness, low installation cost, low operating cost, or a combination of all three—Atlas Copco stationaries are high-performance machines you can rely on.

Sales and Service in Ninety Countries

With companies or agents in ninety countries, Atlas Copco is the world's largest organisation specialising solely in compressed air equipment. Products include stationary and portable compressors, rock drills, loaders, hoists, air tools and paint-spraying equipment. Wherever you are, the international Atlas Copco group offers expert advice and provides a complete after-sales service.



Built to last! This Atlas Copco compressor was installed at the Bofors engineering works (Sweden) in 1907. It is still in operation

WRITE FOR THE LEAFLET

Leaflet E1127 gives full details of the ER6 compressor. Write for a copy to your local Atlas Copco company or agent or to the address below.

Atlas Copco puts compressed air to work for the world

Atlas Copco AB, Stockholm 1, Sweden. In the U.K. Atlas Copco (Great Britain) Ltd., Hemel Hempstead, Herts.

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On the landing-wheels of the D.H. 'Comet'

The undercarriage of the de Havilland 'Comet' is of particular interest since it has a four-wheel bogie, effective in giving improved running on second-rate runways.

As shown in the part section of one of the wheels, special features are the Dunlop high-duty disc brake, used when braking after touch-down, and the motor-driven fan, used to cool the wheels before the next take-off.

The wheels run on Timken bearings.

British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Brazil, Canada, France and U.S.A.

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